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CHARACTERIZING AND UNDERSTANDING THE GROWING POPULATION OF SOCIALLY ENGAGED ENGINEERS THROUGH ENGINEERS WITHOUT BORDERS-USA

by

KAITLIN ILONA LITCHFIELD

B.S., University of New Hampshire, 2011

A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado, Boulder in partial fulfillment

of the requirement for the degree of

Doctor of Philosophy

Department of Civil, Environmental and Architectural Engineering

2014

This thesis entitled:

Characterizing and Understanding the Growing Population of Socially Engaged Engineers through Engineers Without Borders-USA

written by Kaitlin Ilona Litchfield

has been approved for the Department of Civil, Environmental and Architectural Engineering

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Dr. Amy Javernick-Will
(Committee Chair)

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Dr. Bernard Amadei

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Dr. Angela Bielefeldt

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Dr. Daniel Knight

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Dr. Andrew Maul

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Dr. Kurt Paterson

Date__________________

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

IRB protocol # 11-0049

ABSTRACT

Litchfield, Kaitlin Ilona (Ph.D., Civil, Environmental and Architectural Engineering)

Characterizing and Understanding the Growing Population of Socially Engaged Engineers through Engineers Without Borders-USA

Thesis directed by Assistant Professor Amy Javernick-Will

This dissertation studies a group of engineers, who, by intentionally engaging with the social dimensions of engineering, contrasts the engineering stereotype of an antisocial male technocrat. Although US engineering leaders and scholars have advocated for a more broadly skilled, passionate, and diverse population of engineers to help solve pressing global engineering challenges, the field still struggles to recruit, train, and maintain this type of workforce. Therefore, it is important to better understand a rapidly growing group of engineers who appear to contrast the norm because these individuals hold promise for diversifying the engineering population and providing better solutions to global engineering challenges. By characterizing this relatively unstudied population—which this dissertation calls *socially engaged engineers*—this research can support efforts for curricular and programmatic change in engineering education and employee fit and satisfaction in engineering workplaces. The context for this study was Engineers Without Borders (EWB-USA), which is one of the largest and most prominent humanitarian engineering organizations in the US. The main research question that informed this study asked, *how are engineers involved and uninvolved with EWB-USA different and similar?* The research used a sequential, exploratory mixed-methods approach that began with interviews and focus groups with 165 engineering students and practicing engineers across the US and continued with a nation-wide survey to four prominent US professional engineering organizations. To address the research question, similarities and differences between those involved and uninvolved with EWB-USA were analyzed across three main dimensions: personal values (including motivations, interests, and personality traits), learning experiences (including professional and technical skill sets), and career intentions (including students' expectations and practitioners' experiences). The three dimensions correspond to the three main body chapters of this dissertation.

The results showed that EWB-USA members had personal values, technical skills, and both interests and experiences in engineering design and research careers in line with non-members and previous studies of engineers; however EWB-USA members also exhibited altruistic values, professional skills, and broader career interests and experiences that contrasted non-members. Although these results appear in support of socially engaged engineering activities, they also highlight warnings to the engineering field about the misalignment between this growing population of engineers and its historically technocratic and masculine culture. Without cultural changes, the engineering workforce may continue to miss out on engineers who offer diversity, passion, and experience interfacing between the social and technical dimensions of engineering which are needed to better address critical engineering challenges facing society.

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There are many people without whom I would not have been able to complete this dissertation. Here I would like to extend my deep thanks and appreciation to each of these groups and individuals.

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I am exceptionally grateful for the guidance of Dr. Javernick-Will throughout my time at the University of Colorado, Boulder (CU). Even before I arrived at CU, Dr. Javernick-Will was committed not only to my project's success, but also to my own learning and journey through graduate school. Her vast knowledge of and experience with qualitative research led me to think and learn in ways formerly unknown to my technically-focused mind, and her encouragement to continue learning about quantitative research, engineering education, and the many other avenues I grew interest in developed my research skills as well as the breadth of my knowledge. Dr. Javernick-Will has given countless hours mentoring me, reviewing my work, and supporting my growth as a researcher, writer, presenter, educator, student, and person. I am humbly thankful for such a caring and skilled advisor throughout this process.

I am grateful for the help from Engineers Without Borders-USA (EWB-USA) headquarters over the course of the project, especially the extremely helpful Executive Director, Cathy Leslie. Cathy was critical for data collection at multiple stages of the project. She willingly offered her student and industry contacts to help us get the data we needed for a large and robust study of EWB-USA members. This research was also feasible thanks to the additional EWB-USA staff members who aided the distribution of the survey, and to the board of directors who twice listened to presentations of preliminary findings and offered advice for continuing the research down relevant paths.

In addition to providing data collection assistance, Cathy was a part of the advisory panel that helped guide this research through an annual team meeting and as-needed meetings and phone calls. The rest of this team included Dr. Kurt Paterson, Dr. Daniel Knight, and Robyn Sandekian. I am thankful for each of their knowledge and guidance, particularly Dr. Paterson and Dr. Knight for their interests in co-authoring publications from this research and for serving on my dissertation committee.

Two undergraduate research assistants, Casey Casias and Jessica Byrne, each worked on this project for an entire year, for which I am very appreciative. Casey patiently entered over 600 open-ended response forms into Excel, and Jessica provided much-needed qualitative research support. Both students helped with inter-coder reliability, which was an important component of the research.

I am grateful for the staff at American Society of Civil Engineers, American Society of Mechanical Engineers, and the Society of Women Engineers for their assistance with data collection for the national survey and for the University of Colorado's College of Engineering and Applied Science for their help soliciting the students for the pilot survey.

Within the College of Engineering and Applied Science at CU, I am thankful for Dr. Angela Bielefeldt and Dr. Bernard Amadei of the Civil, Environmental and Architectural Engineering department who willingly gave of their time and energy to guide my research and to serve on my dissertation committee. I am also thankful for the Mortenson Center of Engineering for Developing

Communities, which was the primary reason I first applied to graduate school at CU. The Mortenson Center's unique focus on educating students who are interested in applying engineering in a humanitarian context not only drew me to CU and my research, but it also stands as a valuable example of engineering education programs in line with the outcomes of this research. I value the center's support during my time at CU and their model to other universities.

As an interdisciplinary researcher, I must also thank the "non-engineers" who supported my research from the School of Education at CU. The School of Education provided me with half of my graduate school coursework by graciously allowing me into their courses. I am thankful for the patience and teachings of Dr. Margaret Eisenhart, Dr. Susan Jurow, and Dr. Kevin O'Connor as I learned qualitative research methods and analysis. I am also extremely thankful for the sixth member of my dissertation committee, Dr. Andrew Maul from the School of Education. Dr. Maul's expertise in measurement theory and quantitative analyses and his remarkably clear and effective teaching were critical for helping me analyze and understand my survey data, and my research is much stronger because of his contributions.

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CHAPTER 1

INTRODUCTION

"Even in an age of global affluence, the main existential pleasure of engineering will always be to contribute to the well-being of his fellow man. ...[M]aturity brings with it the desire to contribute to the communal welfare. The fulfillment of this yearning, I repeat, provides the engineer with his primary existential pleasure." (Florman 1976 p. 147)

In 1976, Samuel Florman penned *The Existential Pleasures of Engineering,* a book that recounts the early history and purpose of the engineering profession—a profession that serves "fellow man." Over time, this purpose faded and many scholars (Lucena 2005; Riley 2008; Seely 2005) argue that post WWII American engineering has, instead, been focused on militaristic, political, and corporate agendas. Despite some international development engineering efforts since WWII, it was not until the early 1990's that humanitarian engineering efforts proliferated (Lucena and Schneider 2008). In this dissertation, I aim to characterize and understand the engineers engaged in this growing movement. I call these *socially engaged engineers*.

This population is important to understand because many believe it offers new life to the current engineering field and the quality of its engineering solutions; however, this population has not been well studied. Today's engineers face monumental challenges, which include but are not limited to, improving American's failing infrastructure (American Society of Civil Engineers 2013), protecting society from environmental and technological threats (Douglas et al. 2009), enhancing global quality of life (National Academy of Engineering 2008b), and providing for basic human rights (UNESCO 2010; United Nations 2013). Previous generations of American engineers have largely looked and thought the same, which has limited the creativity of their solutions (National Academy of Engineering 2002), but many believe that socially engaged engineers—those involved with organizations or programs with an explicit social component such as humanitarian or community service engineering efforts—offer relief. Scholars have noted that these engineers have experience in complex, inter-cultural, hands-on design that extends their skill sets (Amadei and Sandekian 2010; Budny and Gradoville 2011), participate in a more gender-balanced proportion (Amadei et al. 2006; Swan et al. 2014); and are passionate about addressing the complex global engineering challenges that exist in the world today (Lamb 2010). Anecdotally, it seemed that these engineers offered diversity of characteristics and skills to fill needs in the profession, and, in turn, to address societal needs; however, until now, little empirical data existed about this population.

Therefore, this study addressed the need to understand this population of socially engaged engineers, within the context of Engineers Without Borders (EWB-USA). Because EWB-USA is one of the largest and most prominent humanitarian engineering organizations across the US, this population served as a proxy for socially engaged engineers. My central research question asked, *How are engineers involved and uninvolved with EWB-USA different and similar?* I asked this question across themes of personal, educational, and professional dimensions by evaluating these two populations of engineers in their personality traits, motivations to study engineering, technical and professional skill sets, and career intentions (Figure 1-1). Understanding the characteristics of socially engaged engineers will serve as a baseline for engineering educators and engineering employers to make more informed decisions about supporting such activities, and, hopefully, help engineers better address global engineering challenges.

Existing knowledge about socially engaged engineers is scarce. Several existing studies discuss the value of engineering activities such as EWB-USA anecdotally (Amadei and Sandekian 2010; Bourn and Neal 2008; Lamb 2010) and do not provide empirical data. These studies primarily focus on the learning outcomes of students' experiences, which disregard differences among students prior to and following their university educations. Some studies of socially engaged engineers provide empirical data (Bielefeldt et al. 2010; Budny and Gradoville 2011;

Jaeger and LaRochelle 2009; Kaminsky et al. 2012); however, they too focus on student learning outcomes, which are not only difficult to measure (Shuman et al. 2005), but they also disregard differences in characteristics of engineers draw to such experiences. Bielefeldt et al. (2010) warned of the potential differences in this population of engineers: "...particular care must be taken to avoid erroneously attributing student knowledge, skills, and attitude differences to the PBSL [project based service learning] experience itself versus a bias in the population of students that gravitate to these opportunities" (p. 540). Existing studies have focused on learning outcomes without addressing the potential "bias" within this population. In addition, these studies are small-scale, often focusing on one EWB-USA chapter or one university. Distinctive among existing studies, Adam Carberry (2010) analyzed survey responses from 322 engineering students engaged with eight different learning through service (LTS) activities (including EWB-USA) across the US. He measured and assessed students' self-perceived sources of learning, engineering epistemological beliefs, personality traits, and self-concepts toward engineering design. Although this was a larger study than those previously mentioned, and it addressed students' traits beyond solely learning outcomes, this study did not provide a comparison group of non-LTS students.

Collectively, the current literature leaves many gaps for this research to fill. Not only are there needs for large-scale, empirical data using a comparison group, but there is also no existing understanding of practicing engineers involved with socially engaged engineering, who represent a sizeable portion of socially engaged engineers (according to our survey sample population, professional members makeup about 25% of EWB-USA membership), and there is no understanding of socially engaged engineers' career interests. A summary of the literature gaps is shown in Table 1-1 below.

Table 1-1: Literature gaps in previous studies of socially engaged engineers

Central problem: Need to characterize and understand socially engaged engineers			
	Chapter 2	Chapter 3	Chapter 4
Theme	Personal values: interests, motivations, & personality traits	Technical and professional learning experiences and skills	Students' career expectations & practicing engineers' career experiences
Literature Gaps	• No studies of motivations or interests • Missing comparison group for personality traits	• Primarily anecdotal • Small-scale studies of learning outcomes • Missing a comparison group • Challenges measuring skills	• No studies of careers
Collective gap: No inclusion of practicing engineers			

DISSERTATION SUMMARY

This dissertation is comprised of three main body chapters with one central research question, as illustrated in Figure1-1. All three chapters use data from the same mixed methods data collection, and each chapter takes up a distinct focus and theoretical lens. The three chapters have been divided according to a framework by Lattuca et al. (2011) which takes a systems view of understanding individuals to include their inherent characteristics, their educational experiences, and their future career paths. Comparing EWB-USA members and non-members in these three different areas provides a more comprehensive comparison than merely a focus on learning experiences. In the following paragraphs, I present a brief summary about each body chapter. Further sections of this introductory chapter describe the research context, methods, and the document's format. Overall findings and contributions are discussed in Chapter 5.

The first main body chapter (Chapter 2) begins with a question of whether or not socially engaged engineers hold distinct personal characteristics and values. I demonstrate that EWB-USA members identify as, "I am an engineer AND," meaning, they hold traits and values similar to many other engineers, but they also hold distinct traits and values less associated with engineers. Drawing on social cognitive career theory (Lent et al. 1994) and expectancy-value theory (Eccles 1994)—two mainstream theories relating personal motivation and career choice—I explore and test differences in personality traits and motivations to study engineering. Results showed that

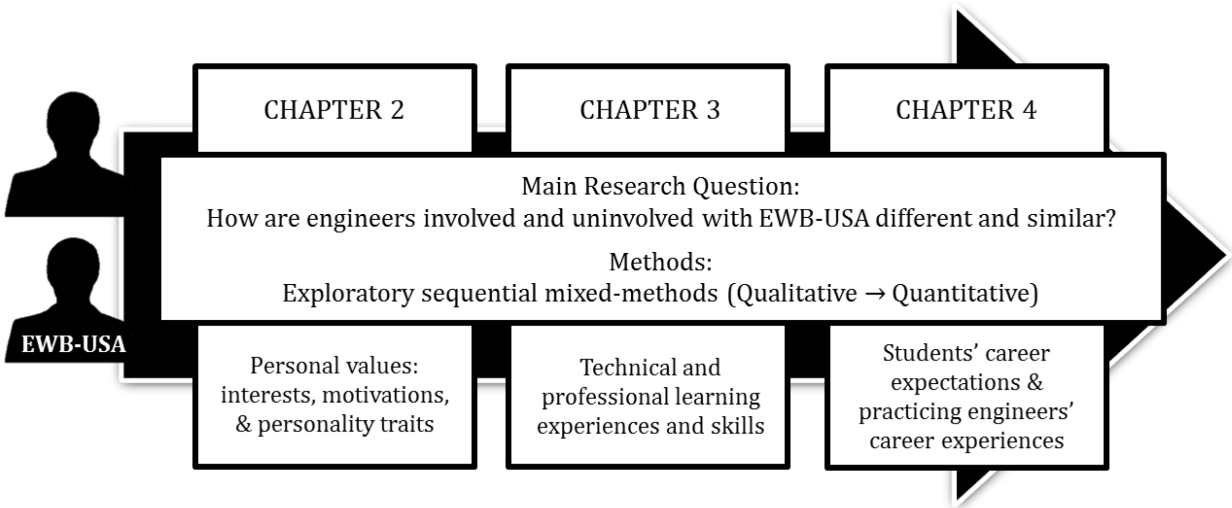

Figure 1-1: Dissertation summary

EWB-USA members had personality traits and motivations in line with many other studies of engineers and the other engineers in this study; however, results also demonstrated EWB-USA members' broader interests, traits and motivations. In other words, these engineers were very much engineers, but they differed in that they valued social dimensions of themselves and engineering more than those not involved in EWB-USA. Implications of these findings suggest that socially engaged engineers help relieve many of the needs facing the engineering population—specifically, lagging numbers, diversity, and preparedness—due to an improved sense of personal and vocational alignment.

Chapter 3 explores the differences in technical and professional skill sets between EWB-USA members and non-members. I present a framework based on experiential learning theory (Kolb 1984) that helps compare learning experiences between EWB-USA members and non-members specific to the engineering activities that they are involved with beyond formal learning environments. Using Shuman et al.'s (2005) distinctions of technical and professional ABET learning outcomes (ABET 2011) and four additional literature-based outcomes (Center for the Advancement of Scholarship on Engineering Education 2005), I compare learning experiences and measures of perceived technical and professional skills between the two groups. Results indicated that EWB-USA members perceived themselves to have higher professional skills than non-members without the sacrifice of their technical skills. Qualitative evidence and the theoretical framework support a causal explanation for this, where EWB-USA members' unique experiences with realistic, complex, and contextualized learning aid their professional skills. Generalizability to other socially engaged engineers is also supported. These results reveal that socially engaged engineering experiences beyond formal learning environments can help to create the skill sets that others (e.g., National Academy of Engineering 2004; Sheppard et al. 2008) claim will help to address complex global engineering challenges.

Finally, Chapter 4 investigates differences in the career intentions and experiences of EWB-USA members and non-members. Students' career expectations and practicing engineers' career experiences are explored separately, and then the misalignment between students' expectations and practitioners' realities is discussed. Drawing on a theory of meaningful work, which underscores the importance of finding personal fit with one's career (Pratt and Ashforth 2003; Wrzesniewski 2003), two warnings to the engineering field are made: (1) female socially engaged engineers may face disillusionment when transitioning into the engineering workforce, and (2) socially engaged engineers may need to employ strategies to cope with tensions of finding meaningful work in a field that generally does not display the same sociotechnical values as these engineers. More so than the previous two chapters, this chapter challenges the engineering culture to be more in line with those whose skills and diversity it claims to seek.

Altogether, the three main chapters point to both similarities and differences between EWB-USA members and non-members. The similarities stress that EWB-USA members are no less engineers than their peers, which counters those who argue that socially engaged engineering waters down the rigor of engineering. The differences stress that EWB-USA members have traits, skills, and career intentions that expand beyond current perceptions of who engineers are and what they can do, and they stress that the engineering field may not be prepared to receive these engineers which they desire. By generalizing to other socially engaged engineers, these findings should influence engineering educators, employers, researchers, and engineers themselves to make informed decisions about socially engaged engineering opportunities. In summary, this research characterizes socially engaged engineers as a unique set of engineers that should be well understood to help make necessary changes in engineering culture and, in turn, influence the quality of engineering solutions. More detailed contributions are shared in the concluding chapter.

Research Context

As mentioned, the context for this study of socially engaged engineers is EWB-USA. "EWB-USA is a nonprofit humanitarian organization established to support community-driven development programs worldwide through partnerships that design and implement sustainable engineering projects, while creating transformative experiences that enrich global perspectives and create responsible leaders" (EWB-USA 2014). Since its inception in 2002, EWB-USA has grown to over 14,700 members with 286 student and professional chapters around the US (EWB-USA 2014). EWB-USA provided a valuable context for this research for many reasons, including, its original chapter having begun at the University of Colorado, Boulder; its national headquarters being located in Denver, Colorado; its Executive Director, Cathy Leslie, being a co-PI on the NSF-REE grant (Grant No. 1129178) to aid with data collection; its large and geographically spread membership throughout the US to aid generalizability; its student and professional chapters to expand the study beyond formal educational settings; and its prominence in the engineering service literature (Carberry 2010; International Journal for Service Learning in Engineering: Humanitarian Engineering and Social Entrepreneurship 2012; Schneider et al. 2009; Swan et al. 2014). Throughout the dissertation, I refer to this same research context.

Research Methods

The methods for this research followed a sequential exploratory mixed methods strategy (Creswell 2009). Creswell recommends this approach for exploratory studies because collecting rich qualitative data early in the study allows for emergent themes to rise and inform further quantitative hypothesis testing. In the following sections, I briefly describe the methods for data collection and analysis for both the qualitative and quantitative phases. A summary of the methods is shown in Figure 1-2.

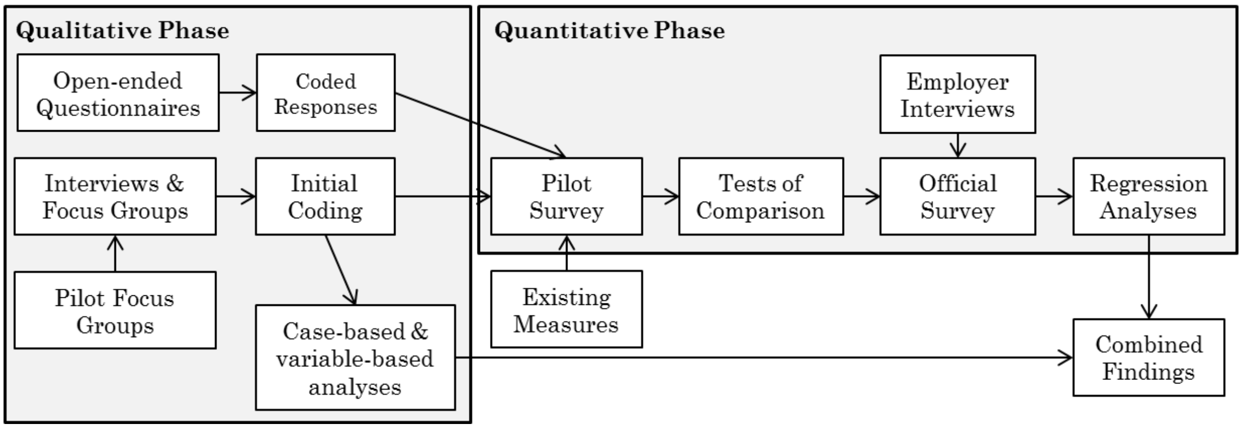

Figure 1-2: Summary of research methods

Qualitative Data Collection

Qualitative data collection began in the fall of 2011. Pilot focus groups with students and practicing engineers were held to test questions following initial research topics of interest including motivations, identity, and outcome expectations. Analysis of the pilot focus groups informed additional interview and focus group questions, and their results were shared in proceedings of the 2012 Construction Research Congress (Kaminsky et al. 2012) (see Appendix A for a full list of publications associated with this project). Simultaneously, open-ended questionnaires were collected from seven EWB-USA fall 2011 regional conferences, in which 659 EWB-USA members participated. These questionnaires used a novel data collection method, fondly referred to as "stickies" because the one-page handout resembled six colorful Post-it® notes, which collected an open-ended response in each box corresponding to questions posed by a conference session moderator. Questions focused on perceptions of self, an engineer, and an EWB-USA member, and on what an engineer needs to know, gaps in engineering education, and gains from EWB-USA involvement. Results from this analysis have already been published (Litchfield, Javernick-Will, and Paterson 2014; Litchfield and Javernick-Will 2014) and are not shared in this dissertation; however, these results helped to inform the creation of the pilot survey.

Qualitative data collection continued through the end of 2012 with 27 total interviews and 32 total focus groups. Altogether, there were 165 participants, 105 of which were EWB-USA members, and 60 of which were non-members. Additional demographic breakdowns of this population, the methods used to solicit them, and examples of questions that they were asked are further described in the subsequent chapters. All sessions were audio recorded (see Institutional Review Board (IRB) approval in Appendix F), which aided the descriptive validity of the subsequent analyses (see Appendix B for details about the qualitative methods and analyses).

Qualitative Data Analysis

Qualitative data analysis consisted primarily of coding using NVivo 10 software (QSR International 2013). The open-ended questionnaires were transcribed into Excel files that were uploaded into NVivo. Within each open-ended question, responses were coded for emergent themes using a coding dictionary and multiple coders to check for inter-coder reliability (see detailed methods in published papers). Following this method, transcriptions from the interviews and focus groups were also coded for emergent themes. Initially, each transcript was coded at a macro level based on the interview or focus group questions. Within each macro code, sub-codes were developed based on response themes. A coding dictionary (see Appendix B) of over 250 codes was maintained throughout this process to keep track of codes and to aid inter-coder reliability. From comparisons of relative frequencies of response themes between EWB-USA members and non-members, my research team and I developed hypotheses for the pilot survey.

Further qualitative analysis paused during the start of the quantitative phase. Once the main topics of comparison were finalized after the pilot survey, additional qualitative analysis resumed. This time, variable-based and case-based approaches were used to more thoroughly analyze the data. A variable-based approach compares themes across cases to compare trends across groups, while a case-based approach studies each case in depth to look for literal and theoretical replication (Miles and Huberman 1994). In the case-based approach, each interviewee was studied in depth. Trends were then triangulated with focus group participants (this approach was primarily used in Chapter 4). Variable-oriented techniques such as grouping and summarizing informed the presentation of the data using overall trends and representative quotes. A reduced version of the coding dictionary used for results presented in Chapters 2 through 4 is shown in Appendix B.

Survey Development & Data Collection

Themes for the pilot survey originated out of the qualitative data (see Appendix C for survey themes, items, and scale sources). Based on these themes, previously validated scales were researched. Where possible, I used existing scales; where previous scales did not exist or did not seem appropriate for this research, items were created. The survey was piloted at the University of Colorado, Boulder's College of Engineering and Applied Science due to ease of access and their large EWB-USA chapter. Through email solicitations, the college's total population of 5,275 students received a link to the anonymous survey hosted in Qualtrics software. The survey stayed open for 19 days during the fall of 2013 (see Litchfield, Javernick-Will, Knight, et al. 2014 for more details about the pilot survey.)

Following analysis of the pilot survey, a few survey items were modified prior to disseminating the official survey to memberships of EWB-USA, American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), and Society of Women Engineers (SWE) (see Appendix C for final survey changes). Members were solicited from their organizations' headquarters via email asking for participation in an NSF funded research in engineering education project. The survey was left open for one month early in 2014. Further details about this data collection are shared in the following chapters.

Quantitative Data Analysis

Analysis of the pilot survey results focused on tests of comparison between EWB-USA members and non-members. Of the 566 final respondents, 51 (9%) were EWB-USA members. Because most of the data was categorical or ordinal, non-parametric Mann Whitney U tests were to compare EWB-USA members and non-members using SPSS. The results of the pilot survey were disseminated through two proceedings at the 2014 American Society of Engineering Education (ASEE) conference (Litchfield, Javernick-Will, and Knight 2014; Litchfield, Javernick-Will, Knight, et al. 2014). These results demonstrated two important changes for the final survey: (1) some items needed to be changed due to potential confusion either by the participants or during interpretation of the results, and (2) regression analyses were a more accurate method to use with the final survey data because they can control for important confounding variables such as age and gender.

The official survey collected 2,896 responses, 25% of which were from EWB-USA members. For all three of the following chapters, those who did not study engineering and those who were not US citizens were dropped from the analysis. Additional respondents were dropped for analysis in each of the three chapters individually depending on the chapter's focus. Primarily respondents were dropped for missing data necessary for analysis. In each chapter, regression analyses were run to compare EWB-USA members and non-members along specific themes. Regression models and variables differed in each chapter based on the relevant theory and the variables of interest (see Table 1-2 for summary). For example, GPA was included as a control variable for Chapters 2 and 3 but not Chapter 4 because GPA was believed to influence choices for field of study and skill levels, but not career expectations. Chapter 2 studied traits about EWB-USA members believed to exist prior to their decision to join EWB-USA, whereas the subsequent chapters asked about traits that may have been explained by EWB-USA membership; therefore, Chapter 2 used EWB-USA membership as the outcome variable whereas Chapters 3 and 4 used membership as the main predictor variable. This difference was a consequence of the assumptions necessary for a causal argument, which includes the proper temporal sequence (Agresti and Finlay 1997). Chapter 4 used fewer control variables to allow for richer discussion of the qualitative data and the combined mixed-methods implications.

Table 1-2: Summary of regression analyses in dissertation chapters

Chapter	Regression Model	Outcome variable	Main predictor variable(s)	Control variables (primary)	Additional control variables
2	Multiple logistic	EWB-USA membership (dichotomous)	Personality trait or motivation	Age, gender, org. participation level, GPA, minority status, family member engineer	ASCE, ASME, or SWE membership
3	Multiple linear	Continuous measures of technical and professional skills	EWB-USA membership & engineering service participation	Age, gender, GPA	Org. participation level; ASCE, ASME, or SWE membership
4	Multiple logistic & ordinal logistic	Responses to career skills and career roles	EWB-USA membership	Age, gender	N/A

Dissertation Format

This dissertation has been written in journal article format; each main body chapter is intended to stand as its own article. Chapter 2 is under review at the *Journal of Engineering Education (JEE)* as an empirical article. An earlier version of Chapter 3 was reviewed as an empirical article by *JEE*, which has been edited in response to reviewers' comments and resubmitted for publication at *JEE*. Chapter 4 is intended to be submitted to *Engineering Studies*, due to the journal's focus on generating critical understanding of engineering. Rather than cite this dissertation, I request that any references to Chapters 2, 3, and 4 of this dissertation cite the published articles. At the conclusion of each chapter, chapter specific references are included, and a list of complete references cited throughout the dissertation is included after Chapter 5. Following the main body chapters, I conclude in Chapter 5 with summaries of theoretical and practical contributions as well as limitations and ideas for future work. The attached appendices provide additional details about (A) publications associated with this research, (B) qualitative analyses, (C) survey themes and items, (D) measurement work and statistical analyses, (E) lessons learned, and (F) IRB approvals.

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CHAPTER 2

'I am an Engineer AND': A Mixed-Methods Study of Socially Engaged Engineers

ABSTRACT

Background – The engineering field is concerned with needs for more engineers, diversity, and globally prepared engineers; however, theory suggests that these challenges indicate a more central challenge, that is, the misalignment between engineers' personal values and their vocations. At the same time, socially engaged engineering activities do not appear to experience the same challenges, which suggests their success at aligning personal values and vocations for a broader group of engineers.

Purpose/Hypothesis – This research investigates the similarities and differences in personal values for engineers both involved and not involved in one of the most prominent engineering service organizations in the US, Engineers Without Borders (EWB-USA).

Design/Method – Using a sequential mixed-method approach that combined variable-oriented analysis of interviews and focus groups with 165 engineers with multiple logistic regression models from responses to a national survey of over 2,000 engineers, we compared and contrasted engineers' personality traits and motivations to study engineering.

Results – Results indicated that EWB-USA members and non-members both exhibited strong engineering personality traits and intrinsic engineering interests and motivations; however, results also indicated that EWB-USA members showed significantly stronger personality traits for openness to experience and agreeableness, higher motivations for social good, and broader interests than non-members.

Conclusions – EWB-USA engineers were found to hold common engineering values similar to non-members AND to have broader values than other engineers. These results suggest that challenges such as lagging numbers, diversity, and preparedness may be addressed through better alignment between engineers' personal values and the engineering profession, particularly by better incorporating social engagement.

INTRODUCTION

> *I want engineering to matter. I want to have an impact. I think there is a selfish part where you want to say that you did something good, but I think that motivates a lot of people, and I'm no different in that way. I think [Engineers Without Borders] is definitely fulfilling the other part of me that isn't an engineer. (FES32)*

What is *"the other part of me that isn't an engineer*"? For this female engineering student, Engineers Without Borders (EWB-USA) fulfills that "other part" of her. This research compared and contrasted engineers involved and not involved with EWB-USA in order to highlight the unique personal attributes of a growing group of engineers who, like this young woman, identify as both engineers AND something more.

Recent work has begun to speak of the need for engineering 'AND,' focusing particular attention on engineering *and* social engagement: engineering *and* sustainable community development (Lucena et al. 2010; Schneider et al. 2008), engineering *and* humanitarianism (Amadei and Wallace 2009; Moskal et al. 2008; Muñoz and Mitcham 2012; Passino 2009), engineering *and* social justice (Catalano and Baillie 2006; Riley 2008), engineering *and* peace (Vesilind 2005a). These are just a few of the 'AND' terms used to refer to a "new interdisciplinary thrust of engineering [that] can be expected to emerge" (UNESCO 2010 p. 59) and has already begun to emerge (Schneider et al. 2009). We call these socially engaged engineering fields. In this paper, we argue that the growth of these socially engaged engineering fields is a manifestation of engineers' struggle to reconcile the alignment of their personal values with their vocations.

Although issues of lagging numbers, diversity, and preparedness of engineers are all important struggles within engineering, theory suggests that these issues may be only symptoms of a deeper issue, that is, the misalignment of engineers' core values and the expression of those values in their vocations. Furthermore, within socially engaged engineering activities, researchers have noted the rapid growth (Lucena and Schneider 2008), atypical gender balance (Bielefeldt 2006), and potential for acquiring broader skill sets (Budny and Gradoville 2011; Lamb 2010), which indicate at least partial relief of the lagging numbers, diversity, and preparedness—the symptoms—plaguing the engineering field. In this research, we study EWB-USA members , participants in one of the most prominent engineering service organizations in the US, as a specific group of engineers involved in socially engaged engineering activity in order to identify their unique personal values and shed light on the importance of addressing the underlying issue of personal and vocational alignment for the engineering field.

BACKGROUND

Symptoms of a Larger Problem

Current challenges in the engineering field most often focus on three primary issues: the shortage of trained engineers, the lack of ethnic and gender diversity, and the need for better prepared engineers (McKenna et al. 2014). Arguments in favor of alleviating these issues reason that engineers are important players in relieving outstanding national and global needs (Butz et al. 2003; National Academy of Engineering 2004, 2005a; UNESCO 2010). Further, the National Academy of Engineers (NAE) claims that "engineers with different ethnic, gender, and cultural backgrounds bring a variety of life experiences to the workplace that, if wisely managed, can encourage creative approaches to problem solving and design" (NAE 2002 p. 4). Although these challenges are important, a review of two dominant theoretical perspectives on career motivation and choice shows that these issues may not be the core problem.

Social Cognitive Career Theory (SCCT) brings together social cognitive theory and career development theory to explain career interests, choices, and performance, and it has been well-studied and applied within math and science professions (Lent et al. 1994). Simplified, SCCT states that personal background and traits (e.g., self-efficacy and outcome expectations) influence interests, which then influence personal goals and actions (Lent and Brown 2006). In their study of gender, ethnicity, and SCCT variables predicting engineers' academic achievement, Hackett et al. (1992) found strong correlations between personal traits including self-efficacy, outcome expectations, and personal interests. Others have extended the use of this theory to understand women's choices around persistence in the engineering workplace (Fouad and Singh 2011).

Similarly, expectancy-value theory (EVT), developed by Eccles (1994), has been used in science, technology, engineering and mathematics (STEM) fields to explain achievement-related choices and performance. Greatly simplified, this model claims that expectations of success and subjective task values influence career choices. Four types of subjective task values are included in the model—enjoyment value (interest), attainment value (the link to personal identity), utility value (to help achieve a goal), and relative cost (Eccles 2007). Using this theory to study engineering students' persistence, Matusovich et al. (2010) found that alignment with sense of self ("attainment value") was the most important indicator for persistence. McGrath et al. (2013) similarly studied persistence in freshmen engineering students and found that enjoyment value ("intrinsic interest") was the most influential value for persistence. Overall, research using the expectancy-value model has shown that expectancies predict achievement and personal values predict career choice (Jones et al. 2010).

Within engineering, EVT has frequently been used to understand gender differences in engineering claiming that gendered differences in values result in gendered differences in occupational choice. In particular, Eccles (1994) has noted women's value of human-centered, helping professions, which are often not associated with math and physical sciences. Other researchers have found that in general, women have a stronger interest in people and social professions than in things and technical professions, which contributes to having fewer women in engineering (Faulkner 2007; Hewlett et al. 2008; Woodcock et al. 2012). While EVT and SCCT have been primarily applied to study gender differences in engineering, both theories indicate that the alignment between personal values and the engineering profession are critical for engagement with the field. As Ayre et al. (2013) point out, many similar models using terms such as "sense of belonging," "identity" or "fit" support this idea. It then follows that a misalignment between personal values and engineering contributes to not only a low number of female engineers, but also to a lower number of interested engineering students and practitioners in general, particularly among those with interests broader than solely technical.

In light of SCCT and EVT, the lagging numbers, diversity, and preparedness among engineers may be only symptoms of a core problem of misalignment between personal values and the engineering field. Although it is tempting to view any one symptom as the main issue within engineering, historical data of women in engineering in the US suggests otherwise. For example, the percentage of women in undergraduate engineering programs has remained stagnant at about 20% for over ten years (National Science Foundation 2013). From their ethnographic study of women working within the margins of science, Eisenhart et al. (1998) argue that it is the nature of science and its inherent biases by those who have historically defined science, that have contributed to the stagnation of females and minorities joining STEM fields. Riley (2008 p. 107) reiterates this point by specifying that, "engineering has largely reflected the values of mainstream society and of neoliberal, military and corporate interests." Similarly, Lucena (2005) notes that plateaued female and minority participation in engineering should be addressed by critiquing cultural biases within engineering itself. In other words, researchers are noting that, historically, the field of engineering has aligned with the values of a specific group of people, and that, instead, engineering should be adjusted to align with the values of a larger group of people. Simply addressing the symptoms of lagging interest, diversity, and preparedness in engineering falls short of the core issue of misalignment between personal values and the engineering vocation.

Engineering 'AND' social engagement

Amidst this central issue and its multiple symptoms, new engineering activities that add a social engagement dimension have emerged. The examples listed in the introduction (e.g., engineering and sustainable community development), have been proposed as titles for an engineering discipline that combines an interest in engineering with a desire to help people. Schneider et al. (2009) have grouped such activities under the umbrella term, "engineering to help," but due to concerns about perpetuating a "need/help conceptual model" (Schneider et al. 2009 p. 45), we have chosen the term socially engaged engineering fields.

The idea of engineers helping people and serving societal needs is not new; engineers have been regarded as civil servants for centuries (Vesilind 2005a). However, since the mid 1900's, engineering education has focused on mastery of basic sciences (Lucena et al. 2010) and has contributed to engineers' challenges working on sociotechnical issues (NAE 1991). In their 1985 report titled *Engineering in Society*, the National Research Council (NRC) (1985 p.51) recommended that, engineers should be prepared, "not just from a technical standpoint, but on a social basis as well," because, as others have noted, successful engineering solutions cannot be separated from social, political, and economic matters (NAE 1991). Since the NRC's recommendations, there has been an explosion of socially engaged engineering initiatives in the last decade (Lucena and Schneider 2008), many of which share a common vision for engineers who "understand the global (physical, social, political, cultural, environmental, legal and economic) constraints that they face and how to use the available tools as they consider the long view, while working to meet the needs of local people" (Muñoz and Mitcham 2012 p. 55). Examples of these initiatives include senior design at the University of Pittsburgh (Budny and Gradoville 2011), the D80 Center at Michigan Technological University (Paterson and Fuchs 2007), the Humanitarian Engineering department at the Colorado School of Mines (Moskal et al. 2008), the Engineering for Developing Communities program at the University of Colorado (Amadei and Sandekian 2010), and socially engaged engineering organizations such as EWB-USA (and similarly named organizations all over the world), Engineers for a Sustainable World, Engineers for Change, and Bridges to Prosperity, to name a few.

The growth of such programs and organizations parallels the maturing of the Millennial Generation that has become known for wanting to make a difference (Greenberg and Weber 2008). As Greenberg and Weber (2008) note, the "we" generation (those born between 1978 and 2000) has a unique passion to solve the world's problems and bring about change. Through increased awareness of global issues such as those provided in the Millennium Development Goals (United Nations 2013) and through marketed changes in public perceptions of engineering—to emphasize "that engineering and engineers can make a difference in the world" (NAE 2008 p. 11)—more young people are learning that engineering is a way to design solutions for humanity and use their passion to bring about change in the world. As a result, many Millennials have found that socially engaged engineering activities allow them to align their personal values with engineering. In speaking about these new, younger engineers, Andrew Lamb (2010) writes that, "They had, arguably, a much more global worldview than the generations of engineers who came before them, and they were very concerned about global issues. Their new perspective demanded a new engineering expression, and many chose EWB" (p. 163).

Research Questions and Hypotheses

As mentioned in the introduction, scholars (e.g., Lucena and Schneider 2008; Bielefeldt 2006; Budny and Gradoville 2011; Lamb 2010) have noted that many socially engaged engineering activities contrast the field's symptoms of a shortage of interested engineers, lack of diversity, and insufficient broad and global preparedness. Based on the aforementioned theories, we believe that these differences within socially engaged engineering activities can be partially explained by improved alignment between personal values and engineering that social engagement brings. In order to test this claim, our research studies the differences and similarities in values between engineers involved and not involved in socially engaged engineering. If our claim is true, we would expect that the two groups share similar values for engineering ('I am an Engineer'), and that the socially engaged engineers show different, broader values ('I am an engineer AND').

We have chosen EWB-USA members for the context of our study due to EWB-USA's prominent role as a socially engaged engineering organization. Beginning in 2002, EWB-USA has grown to over 14,700 members who have worked in 39 different countries (EWB-USA 2014). In addition, EWB-USA has claimed 43% female membership (Amadei and Sandekian 2010), and members have been found to gain additional professional skills when compared to their peers (see Chapter 3). As a result, EWB-USA represents a socially engaged engineering organization that contrasts the symptoms of low interest (with rapid growth in twelve years), lack of gender diversity (with over twice the female to male ratio of the typical engineering setting), and need for better preparedness (with strong professional skills). In order to understand differences in personal values between engineers involved with and not involved with socially engaged engineering, this research analyzes engineers both involved and not involved with EWB-USA across the United States.

We used a sequential mixed-methods approach (Creswell 2009) in order to explore the differences and similarities in values between EWB-USA members and non-members, starting with interviews and focus groups that informed a subsequent questionnaire. For the qualitative phase, we explored the personal values deemed important from SCCT and EVT, particularly identification and intrinsic interests (especially an intrinsic motivation for studying engineering). We aimed to address the following research questions:

1. Do EWB-USA members and non-members identify as a typical engineer? Why or Why not?
2. Do EWB-USA members and non-members have different intrinsic motivations for studying engineering or pursuing their other interests?

Based on patterns from the qualitative responses, we then created a questionnaire that would allow us to test the qualitative trends, which focused on differences in personality traits and motivations to study engineering. This phase hypothesized that:

1. EWB-USA members and non-members have similar engineering personalities
2. EWB-USA members have more social and open personalities than non-members
3. EWB-USA members and non-members have similar intrinsic engineering motivations
4. EWB-USA members have more socially-motivated engineering motivations than non-members.

The following sections begin with the methods and results from the qualitative portion of the study, continue onto the methods and results from the quantitative phase, and then discuss the findings across both methods.

QUALITATIVE PHASE

Data Collection

Over the course of eighteen months between 2012 and 2013, 165 engineers participated in 27 individual interviews and 32 focus groups held across the country. One hundred five of these participants were EWB-USA members, 85 were male, and 90 were students. EWB-USA member participants were solicited through EWB-USA conferences and chapters based on snowball sampling to ensure appropriate coverage of our desired demographics, which included males and females, and both students and practitioners. Where possible, non-member participants were solicited from the same locations as the EWB-USA member interviews and focus groups through contacts at nearby engineering colleges and companies.

Three different gender balances were created in the focus groups: all male, all female, and mixed gender; students and professional engineers as well as EWB-USA members and non-members were not mixed in the focus groups. Interviews lasted approximately 40 minutes and focus groups approximately one hour, both of which followed a semi-structured approach (Spradley 1979). Question topics included engineering identities and motivations for engineering and other activities. For example, participants were asked, Why did you choose to study engineering? Would you describe yourself as a typical engineer? (Why or why not?) How do you spend your time outside of the classroom or workplace? One to two members of the research team conducted the focus groups, and all interviews were held one-on-one. In accordance with IRB regulations, all sessions were recorded either in person or over the phone after collecting participant consent, and participants were offered either snacks and refreshments or a $10 gift card for their participation.

Data Analysis

Over 36 hours of audio recordings were transcribed, checked for accuracy, and uploaded into qualitative coding software QSR NVivo 10. Initial coding was primarily descriptive, and it began at the macro level using deductive codes based on the original themes of identity and motivations. Additional coding identified emergent themes within each macro code. Following the recommendations by Miles and Huberman (1994), a coding dictionary was kept during the coding process that included a rule for inclusion for each of the macro codes and a definition for each of the sub-codes. For engineering motivations, we coded responses to align with the six main engineering motivations that Sheppard et al. (2010) found in a literature review: financial, parental influence, social good, mentor influence, intrinsic psychological, and intrinsic behavioral. These last two variables—intrinsic motivations—are important motivations that have been correlated with an intention to complete an engineering degree among engineering students, and the two have been defined as "motivation to study engineering for its own sake, to experience enjoyment that is inherent in the activity" (psychological) and "motivation related to the practical and hands-on aspects of engineering" (behavioral) (Sheppard et al. 2010 p. 8). We also added two common response themes to the six original engineering motivations: "EWB or similar work" (when EWB-

USA or a similar activity was referenced explicitly) and "other" (capturing unique responses such as a camp someone attended). We employed a variable-oriented approach for analysis (Miles and Huberman 1994), in which we compared the main emergent themes across cases to find patterns. We used both counts of relative frequencies of responses and clustering techniques to summarize the findings. For reporting the results, each participant was labeled using the following format: the first letter (F or M) designated female or male, the second letter (E or N) designated EWB-USA member or non-member, the third letter (S or P) designated student or practitioner, and the number was a unique identifier.

Results- Interests in and Identification with Engineering

Due to the semi-structured nature of the questioning, many participants did not give straightforward answers that could be neatly coded and counted. This was especially true for questions about identification with engineering. In general, about one quarter of participants responded that they were not the typical engineer and less than a tenth claimed to be a typical engineer. Both EWB-USA members and non-members denied identification with the engineering stereotype more frequently than they identified with it. Given the harshness that often comes with the engineering stereotype, for example being poor with social or communication skills or being technically focused, (Riley 2008), the less frequent identification as a typical engineer made sense.

Because both EWB-USA members and non-members preferred to disassociate with the typical engineer identity, we then examined their reasons for this response. Those not involved with EWB-USA explained that they were not the typical engineer for reasons that included liking hands-on work or English class; having social lives or a sense of humor; being well spoken, more politically involved, or a blonde girl (FNS16); and some not liking to sit at a computer all day. In general, respondents not involved in EWB-USA provided simple explanations as to why they were not the stereotypical engineer. For instance, a male student stated, "*There's a big stigma that engineers can't talk to people; they just want to sit in their cubicle and do equations all day, and I* *know for a fact that's not what I want to do. I'd rather be out in the field talking to people*" (MNS5). This engineer identified his social nature as the key reason he is not a typical engineer.

Some non-EWB-USA members were not sure if they were or were not like the stereotypical engineer wondering if the stereotype of an engineer is outdated: "*I would not describe myself as a typical engineer, but I think part of it is because of the stigma of what a stereotypical engineer is. But as I say that I'm almost starting to think that maybe I am a typical engineer and the stereotypical engineer that I think about is the older generation. … the younger ones are a lot more like me and not as socially awkward as what most people think an engineer is*" (MNP7). Wrestling with the definition of and identification with a typical engineer like this engineer showed was noticeable among this group of participants.

For those within EWB-USA, participants were much more emphatic about their lack of identification with the stereotypical engineer. Many abruptly said that they "*definitely don't*" (e.g. MEP13) see themselves as the typical engineer, citing reasons such as liking and participating in humanities courses; being social, not introverted, musical, or "*the weird… social justice person*" (FES18); liking people or working on teams; having a unique personality that is social, curious, or outgoing; and almost deciding to leave engineering. Many people used the word "broader" to describe their interests or to explain how they were unique in their personalities and their interests in engineering. This was exemplified in the following excerpt from a mixed-gender focus group of practicing engineers involved with EWB-USA:

> *MEP17:* *I think this organization does attract, maybe not the traditional engineer, but a broader vision of engineer. …*
>
> *MEP13:* *I definitely don't see myself as a typical engineer. …[M]y career was originally as a musician, so that already is really different. …When I was working in industry, I felt like I had a broader set of interests in some way that wasn't matching up.*
>
> *FEP4:* *I think that's probably why I didn't go to engineering to begin with because there's a lot of engineers in my family, so I guess I didn't feel like that was who I was…*
>
> *MEP14:* *…I don't know if there's a typical engineer, but I have more interest in the broader interactions of people and it's what draws me to [EWB]…*

FEP4: *Yeah, I think that's a good point. I think the engineers that I've come across in EWB are maybe a little more extraverted than what I typically would think of as engineers.*

MEP15: *Yeah, I guess the first 15 years of my career I was a typical engineer. I thought it was all about technical stuff, and then I started learning defining the problem is harder than solving the problem. What is the real problem? Sometimes it's not clear. And then I started working in construction, a latter part of my career, and I really enjoyed the people interaction and the teamwork more than the technical.*

In this excerpt, three participants used the word "broader" to either describe the type of engineering that attracts themselves or EWB members or to describe their interests. Similarly, one member talked about enjoying the part of engineering that is "*more than the technical*." The female participant specifically talked about not wanting to go into engineering originally because she did not see engineering aligning with who she was, and she noted that EWB-USA members are more extraverted than other engineers—a point echoed by many other participants. One male participant notes that his interests were not "*matching up*" where he worked in industry. This excerpt exemplifies the depth of differences mentioned between the EWB-USA members compared to non-members when discussing identification with a typical engineer.

In comparing responses about interests and activities, both EWB-USA members and non-members mentioned interests in volunteering, sports, friends, professional engineering organizations, outdoor activities, their children, engineering outreach, mentoring, coaching, cooking, and politics. EWB-USA members uniquely mentioned interests in music, religion, traveling, poetry, reading, philosophy, other languages and cultures, and non-profit work. These results are not expected to be true across all EWB-USA and non-EWB members; however, they reiterate the trend of EWB-USA members' more broad interests shown in the previous excerpt.

Results- Motivations to Enter Engineering

Because respondents often shared multiple reasons for entering engineering, and because the majority of participants responded to this discussion topic, we present these results as relative frequencies (number of people who responded in a particular theme divided by the number of people who answered the question). The results, differentiated by affiliation with EWB-USA, are shown below in Figures 2-1 and 2-2, where Figure 2-2 divides the results further by gender. Due to the qualitative nature of the data, no statistical tests were run on the proportions. Instead, these results were used to determine trends for further quantitative testing.

Both EWB-USA members and non-members mentioned an intrinsic motivation as the most common reason for studying engineering, which was consistent with Sheppard et al.'s (2010) findings, and when combined, the two groups mentioned these themes with nearly equivalent frequency. Those not involved with EWB-USA mentioned motivation from family members, teachers or mentors, and a good salary or job security more frequently than members; and members mentioned motivation from EWB or similar type of work, and from a desire to help others more frequently than non-members. Both groups mentioned other motivations nearly equally.

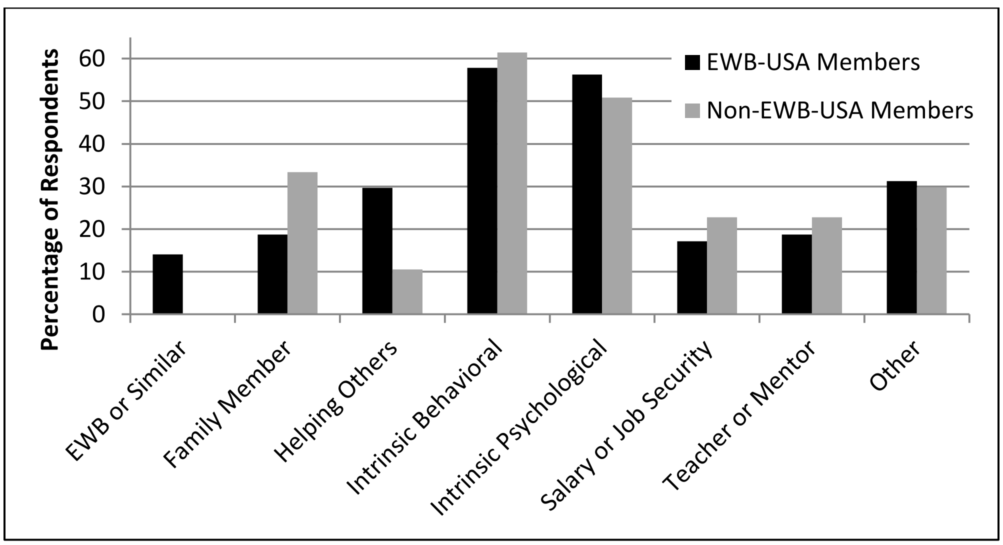

Figure 2-1: Relative frequencies of themes for motivations to enter engineering

In order to make sure that the differences in responses were not solely due to a more balanced gender ratio within EWB-USA, we separated the results by gender (see Figure 2-2). Intrinsic psychological motivations were noticeably less frequent among women. Women not involved with EWB-USA mentioned family-related motivations much more frequently than males and more than EWB-USA women. EWB-USA women mentioned motivation for salary or job security less frequently than men and less frequently than non-EWB women. In addition, EWB-USA women mentioned motivation for engineering through EWB-type work and helping others more frequently than non-EWB women and all men. Interestingly, the women not involved with EWB-USA mentioned helping others as a motivation for studying engineering as frequently as non-EWB males. Literature has found that women are drawn to the people-side of engineering (Faulkner 2007; Hewlett et al. 2008; Woodcock et al. 2012), but these results suggest that social or altruistic motivations may be more true of engineers involved with EWB-USA than women in general.

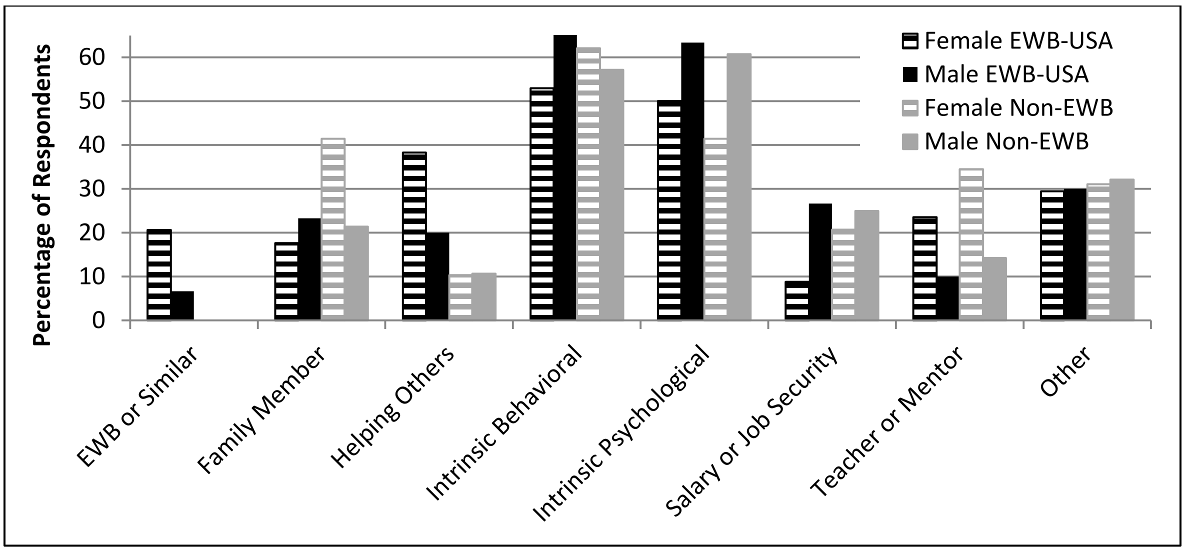

Figure 2-2: Relative frequencies of themes for motivations to enter engineering by gender

QUANTITATIVE PHASE

Item Design

Based on the trends found in the focus groups and interviews, we designed a questionnaire containing items specifically targeting engineers' personality traits and motivations for engineering in addition to asking basic demographic questions. Demographic items included gender, year of birth, race/ethnicity, undergraduate engineering GPA, having an immediate family member as an engineer, and professional engineering organization membership and participation.

Based on extensive work in psychology, a five-factor model of personality traits has been widely accepted: (1) extraversion (being social, gregarious, talkative, etc.), (2) emotional stability (being calm, not anxious or worried, secure, etc.), (3) agreeableness (being friendly, trusting, flexible, etc.), (4) conscientiousness (being dependable, careful, organized, etc.), and (5) openness to experiences (being curious, cultured, broad-minded, etc.) (Barrick and Mount 1991). Silver and Malone (1993) assessed these “Big-Five” personality traits among different occupations (civil engineering, accounting, criminal law, and theater/drama) finding that civil engineers exhibited high emotional stability and conscientiousness and low openness. Carberry (2010) found that engineers engaged in learning through service activities, including EWB-USA, exhibited high extraversion, agreeableness, and openness; however, there was no comparison with engineers not engaged in service.

For our questionnaire, we chose to measure personality traits using the ten-item measure of the Big-Five personality domains developed by Gosling et al. (2003), which allowed us to measure personality traits without overloading respondents with survey items. Following the language used in the original survey, these ten items asked respondents to “indicate the extent to which you agree or disagree” with specific statements about their personality on a seven point scale from strongly disagree to strongly agree. Each trait used one regularly-coded item and one reverse-coded item (see list of traits in Table 2-1).

Items for measuring motivations for engineering came from the Center for the Advancement of Engineering Education’s Academic Pathways of People Learning Engineering Survey (APPLES) (Sheppard et al. 2010). Their sixteen survey items were developed over successive administrations of their survey and group into six main engineering motivation variables (as previously seen in the qualitative phase). Using these six variables, Sheppard et al. (2010 p. 40) found that senior engineering students were most motivated by intrinsic behavioral reasons followed by intrinsic psychological, social good, financial, mentor influence, and then parental influence.

Because our questionnaire was administered to both engineering students and practicing engineers, we combined two of the sixteen items from APPLES into one: instead of asking about both university affiliated and non-university affiliated mentors, we asked about mentors overall. Other minor changes were made to create items inclusive of practicing engineers (e.g. changing "An engineering degree *will* guarantee me a job when I graduate" to "An engineering degree *will/would* guarantee me a job when I graduate"). We also added a variable for community development work that consisted of two items—(1) Engineers Without Borders or a similar type of work interested me, and (2) I wanted to use engineering to do community development projects around the world. This variable emerged as a key motivation for engineering from the qualitative data. All seventeen items used a five point scale ranging from "not a reason" to "an extremely important reason" with the following prompt: "We are interested in knowing why you chose engineering as an area of study. Please indicate below the extent to which the following reasons apply to you" (see list of motivations in Table 2-1).

Table 2-1: Personality traits and motivations for studying engineering on questionnaire

Questionnaire Theme	Trait or Motivation	Number of Items	Cronbach's Alphas	
			Ours	Published
Personality traits	Agreeableness	2	0.35	0.40
	Conscientiousness	2	0.52	0.50
	Emotional stability	2	0.64	0.73
	Extraversion	2	0.74	0.68
	Openness to experience	2	0.41	0.45
Motivations for studying engineering	Community development	2	0.79	N/A
	Family	2	0.68	0.83
	Financial	3	0.83	0.81
	Intrinsic behavioral	2	0.71	0.72
	Intrinsic psychological	3	0.80	0.75
	Mentors	2	0.85	0.77
	Social good	3	0.79	0.77

Data Collection

To populate the questionnaire, we partnered with four large US professional engineering organizations: American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), Society of Women Engineers (SWE) and EWB-USA. Although a random sample of all engineering students and practicing engineers across the US would be ideal, this was not possible. Therefore, we partnered with organizations from which we could solicit engineers with a wide range of geographic locations, ages, and backgrounds. ASCE and ASME were chosen because their engineers work in disciplines similar to many of the EWB-USA projects, and SWE was chosen to provide a higher population of female non-EWB-USA members to compare and contrast the high percentage of females engaged in EWB-USA.

Due to each organization's unique policies, solicitation for participation was different across all four organizations. Either through a random sample selection process or by distribution to every organizational member, participants received an anonymous link to the online survey hosted in Qualtrics survey software. In total 118,036 members received the survey link. The online questionnaire was left open for one month between January and February 2014, with a reminder sent after two weeks.

Data Analysis

In order to analyze the demographic data, we chose to define "member" by either official membership or informal participation based on participants' survey responses. Because this study was focused on EWB-USA members as a case of socially engaged engineers, we wanted to account for other socially engaged engineering involvement. The questionnaire asked participants to indicate whether they were involved with an engineering service curriculum, organization, or program similar to, but not including, EWB-USA. For those who indicated such participation, we asked them to write in the name of their program. These results indicated such a wide variety of programs and organizations that made it difficult to determine whether or not engineering and service were incorporated. As a result, we removed all participants who had indicated involvement in a similar program and were not involved with EWB-USA to remove potentially confounding participants. This helped better attribute results to EWB-USA membership.

In some cases, participants were involved in multiple organizations (e.g., ASCE and EWB); therefore, we could not run tests of proportions to compare demographic information across all four organizations because the categories were not mutually exclusive. Instead, the demographic data compared those involved and not involved with EWB-USA, grouping all other non-EWB-USA organizations together. Using Stata software, chi-square tests of proportions compared counts of females, minorities, and those with an immediate family member in engineering, and t-tests compared mean age and undergraduate GPA.

Items for the personality traits and motivations were indexed in order to create continuous scales. Cronbach's alpha estimates were used to check for internal consistency of items. For the personality scales, the values ranged from 0.74 to 0.35. These results aligned with those found by Gosling et al. (2003) when designing their scales (see Table 2-1). The authors emphasized that the content validity of their items should be emphasized over their reliability which would be weakened due to having only two items. Cronbach's alpha estimates for the motivation scales in our survey were all strong, ranging from 0.85 to 0.68 and were similar to those found by Sheppard et al. (2010).

In order to compare differences in personality traits and motivations between EWB-USA members and non-members we used multiple logistic regression models in which the dependent variable was a dichotomous variable for EWB-USA membership. A separate multiple logistic regression model was run for each personality trait and each motivation (from list in Table 2-1), where the main independent (or predictor) variable in each model was the trait itself. Each model included additional predictor variables as controls to help eliminate potentially confounding variables. For the personality trait models, control variables include a dichotomous variable for being female, a continuous variable for age, and three categorical variables for limited, moderate, and extensive levels of active participation in the organization with "none" as the reference category. Gender and age were used as controls because of the significant differences between

EWB-USA members and non-members from the demographic data. Level of active participation was controlled for because it was believed to be associated with personality traits. For the motivation models, control variables included the same gender and age variables as well as a dichotomous variable for being of a minority race or ethnicity (as done by Sheppard et al. (2010)), a continuous variable for GPA, and a dichotomous variable for having an engineer in the immediate family. Minority status, GPA, and family engineers were all believed to influence motivations to study engineering and were therefore added as controls. A cutoff of alpha equal to or less than 0.01 was used to test for significance to reduce Type I errors.

Results- Demographic Data and Differences

We received 2,674 completed questionnaires, a 2% response rate. Although the response rate was low, it did not flag concerns of self-selection bias because we had no reason to think that the population who took the survey was inherently different from those who did not respond to the survey. The percentages of female respondents (25%) and student respondents (29%) were comparable to the demographics of the initial population (28% female and 31% students), and 25% of the respondents were official EWB-USA members, which provided a large sample to compare with non-members. Organizations did not provide additional demographic information about their populations, so no further comparisons of demographics such as ethnicity and race could be made.

Of the 2,674 respondents, 2,167 questionnaires were ultimately analyzed after dropping respondents without an engineering background, non-US citizens, and those with missing data needed for regression analyses. The decision to drop non-US citizens was made based on this study's focus on background attributes, motivations, and personalities, which can vary greatly in different cultures. Because we aimed to capture differences due to involvement with EWB-USA, and were unable to adequately control for unknown cultural biases, we focused on US-based engineers. As mentioned previously, organizational membership included official or unofficial membership, and those with active participation in an organization similar to EWB-USA as determined by the respondent were also dropped (n=223). Ultimately, these steps resulted in the analysis of responses from 575 EWB-USA members, 964 ASCE members, 1001 ASME members, and 283 SWE members. Because some participants were involved in multiple organizations, there were 1,592 total non-EWB-USA members.

Demographic information and the results from the tests of comparisons between EWB-USA members and non-members are shared in Table 2-2. EWB-USA was found to have significantly more females, as well as a younger group (Cohen's d = -0.50) with a higher mean GPA (Cohen's d = 0.14) than non-members, although the practical difference in GPA was small. Interestingly, the percentage of EWB-USA females was 52% among student members compared to 26% among practitioners. The percentage of minorities in EWB-USA was 21% among students, which was comparable to SWE student members at 22%. These results align with past literature that socially engaged engineering activities attract a more gender balanced engineering population (Bielefeldt 2006), and suggests that increased ethnic/racial diversity may also be present in these activities.

Table 2-2: Questionnaire demographic information and tests of comparison

	EWB-USA Members (n=575)	Non-EWB-USA Members (n=1592)	Test statistic	p-value
% Female	38.8%	21.3%	X^2 = 67.3	<0.001
% Minority	15.7%	12.4%	X^2 = 3.79	0.052
% Engineer in Family	33.2%	35.4%	X^2 = 0.91	0.340
Mean Age	35.5	44.1	t = 10.3	<0.001
Mean GPA	3.39	3.33	t = -2.81	0.005

Results- Logistic Regression for Personalities

The results in Table 2-3 show the odds ratios, standard deviations, and significance levels for six regression models—a reference model and one model for each of the five personality traits. The reference model indicates that age and all three levels of professional engineering organization participation were significant predictors of EWB-USA membership. Gender was approaching significance, but was not significant at the α=0.05 level in this model. Two personality traits were associated with EWB-USA membership when controlling for gender, age, and participation level:

agreeableness and openness to experiences. The odds ratios stated that, for a one unit increase in the agreeableness and openness scales, the odds of being an EWB-USA member were 1.17 and 1.31 times those of being a non-member respectively, controlling for all other variables.

Carberry (2010) found that engineers engaged in service learning activities such as EWB-USA showed high agreeableness and openness as our results found; however, he also found that these engineers expressed high extraversion. When previous iterations of the models were run without controlling for level of professional engineering organization participation, extraversion was a highly significant predictor of EWB-USA membership. By providing a comparison group for EWB-USA members of engineers engaged with other engineering organizations, these results indicated that extraversion was not a unique personality trait of EWB-USA members and that extraversion may be a trait associated with organizational participation in general.

The other two personality traits that were not found to be significant among EWB-USA members—conscientiousness and emotional stability—were the two traits that Silver and Malone (1993) found to be particularly high among civil engineers in their study of personalities across four diverse occupations. Silver and Malone (1993) also found that low openness was a common trait among engineers, which, in the results from this study, was found to be the trait with the most significant differences between EWB-USA members and non-members, with EWB-USA members displaying higher openness to experience than non-members.

Table 2-3: Odds ratios for multiple logistic regression models for personality traits on EWB membership

Variable	Reference	Extraversion	Agreeableness	Conscientiousness	Openness	Emotional Stability
Trait	--	1.03 (0.04)	1.17 (0.06)**	0.91 (0.05)	1.31 (0.08)***	1.05 (0.05)
Female	1.24 (0.16)	1.23 (0.16)	1.16 (0.15)	1.25 (0.16)	1.25 (0.16)	1.26 (0.16)
Age	0.97 (0.003)***	0.97 (0.003)***	0.97 (0.003)***	0.97 (0.003)***	0.97 (0.003)***	0.97 (0.003)***
Limited part.	2.57 (0.60)***	2.56 (0.59)***	2.58 (0.60)***	2.55 (0.60)***	2.60 (0.60)***	2.58 (0.60)***
Moderate part.	3.37 (0.49)***	3.34 (0.48)***	3.42 (0.50)***	3.40 (0.49)***	3.39 (0.49)***	2.27 (0.49)***
Extensive part.	2.04 (0.28)***	2.03 (0.27)***	2.01 (0.27)***	2.04 (0.28)***	1.99 (0.27)***	2.03 (0.27)***
Constant	0.18 (0.05)***	0.16 (0.05)***	0.09 (0.03)***	0.31 (0.13)***	0.04 (0.02)***	0.14 (0.05)***

**p<0.01, ***p<0.001

Table 2-4: Odds ratios for multiple logistic regression models for motivations on EWB membership

Variable	Reference	Intrinsic Psychological	Intrinsic Behavioral	Family	Mentors	Financial	Social Good	Community Development
Trait	--	0.80 (0.05)***	0.81 (0.04)***	0.98 (0.07)	1.02 (0.04)	0.94 (0.05)	1.35 (0.07)***	2.38 (0.12)***
Female	1.71 (0.19)***	1.68 (0.19)***	1.52 (0.18)**	1.71 (0.19)***	1.70 (0.19)***	1.71 (0.19)***	1.72 (0.20)***	1.40 (0.18)**
Age	0.98 (0.003)***	0.97 (0.003)***	0.97 (0.003)***	0.98 (0.003)***	0.98 (0.003)***	0.97 (0.004)***	0.98 (0.004)***	0.99 (0.004)**
Minority	1.04 (0.15)	1.07 (0.16)	1.04 (0.15)	1.04 (0.15)	1.04 (0.15)	1.04 (0.15)	1.06 (0.12)	0.62 (0.10)**
GPA	1.10 (0.13)	1.12 (0.13)	1.07 (0.13)	1.09 (0.13)	1.09 (0.13)	1.09 (0.13)	1.22 (0.16)	1.11 (0.15)
Fam. Eng.	0.96 (0.10)	0.97 (0.10)	0.96 (0.10)	0.97 (0.11)	0.96 (0.10)	0.96 (0.10)	0.94 (0.10)	0.99 (0.12)
Constant	0.62 (0.27)	1.36 (0.67)	1.71 (0.88)	0.64 (0.29)	0.60 (0.27)	0.78 (0.37)	0.22 (0.11)**	0.05 (0.03)***

**p<0.01, ***p<0.001

Results- Logistic Regression for Motivations

The results in Table 2-4 show the results for the motivation models in a format similar to Table 2-3. As all seven models and the reference model show, gender and age were significant controls. Minority status was a significant control only in the model for the community development motivation. Both psychological and behavioral intrinsic motivations were found to be significant predictors where for a one unit increase in the motivational scales, the odds of being an EWB-USA member were 0.80 and 0.81 times those of being a non-member respectively, controlling for the other variables. This meant that EWB-USA members tended to have lower intrinsic motivations for studying engineering than non-members. Social good and community development motivations were also found to be significant predictors with odds ratios of 1.35 and 2.38 respectively, meaning that EWB-USA members tended to score these motivations significantly higher than non-members.

These results seemed to indicate that EWB-USA members had less intrinsic motivation to study engineering and more desire to do engineering for reasons to help others. However, the initial regression models only compared EWB-USA members and non-members without determining whether or not other organizations also had unique motivations. Therefore, in order to better attribute motivations and personality traits to EWB-USA members, we needed similar models for each organization in our dataset.

Results- Comparisons with Other Organizations

The same regression models as those in Tables 2-3 and 2-4 were rerun for the three other organizations—ASCE, ASME, and SWE—using dichotomous outcome variables for members and non-members specific to each organization. The results for the odds ratios of the personality trait or motivation variables only are shown in Table 2-5. The only significant variable for the personality trait models among the other three organizations was openness to experience among ASCE members ($p<0.05$), where ASCE members indicated significantly less openness than non-

ASCE members controlling for other variables. These results indicated that the higher levels of agreeableness and openness were uniquely attributable to EWB-USA members.

For the motivations to study engineering, the results were more complex. First, for intrinsic motivations, ASCE members showed significantly less intrinsic motivations than non-ASCE members, and ASME members showed significantly higher intrinsic motivations than non-ASME members. This suggested that the findings of lower intrinsic motivations for EWB-USA and ASCE members than non-EWB and non-ASCE members respectively may have been due to the higher intrinsic motivations among ASME members than non-ASME members. When ASME members were removed from the dataset and models were rerun, the differences in intrinsic motivations between both EWB-USA and non-EWB members and between ASCE and non-ASCE members were no longer significant. This suggested that the intrinsic differences in motivations within EWB-USA members were not related to organizational involvement and may be more related to one's engineering discipline. In a regression model comparing participants with a mechanical engineering degree and a civil engineering degree, controlling for the aforementioned variables, intrinsic motivations were significantly higher for mechanical engineers over civil engineers, further supporting the initial finding.

In contrast, the two motivations that were significantly higher among EWB-USA members than non-members—social good and community development—were found to be unique to EWB-USA membership. No other organizations showed significant differences between its members and its non-members for the social good motivation. ASCE members were found to have higher community development motivations for engineering than non-ASCE members, and ASME members were found to have lower community development motivations than non-ASME members. When ASME members were removed from the analysis, ASCE members were found to have significantly lower community development motivations than non-ASCE members, and EWB-USA members were found to still have significantly higher community development motivations than non-EWB members. These findings suggest that EWB-USA members are uniquely motivated to study engineering by a desire to do good by helping society and doing community development work.

Table 2-5: Odds ratios for multiple logistic regression models by organization

Trait or Motivation	EWB-USA	ASCE	ASME	SWE
Extraversion	1.03 (0.04)	1.05 (0.03)	0.94 (0.03)	0.98 (0.05)
Agreeableness	1.17 (0.06)**	0.98 (0.04)	1.03 (0.04)	0.98 (0.07)
Conscientiousness	0.91 (0.05)	1.00 (0.05)	0.97 (0.05)	0.97 (0.08)
Openness	1.31 (0.08)***	0.89 (0.04)*	1.09 (0.05)	0.95 (0.08)
Emotional Stability	1.05 (0.05)	0.94 (0.04)	1.01 (0.04)	0.89 (0.05)
Intrinsic Psychological	0.80 (0.05)***	0.83 (0.04)**	1.29 (0.07)***	0.89 (0.08)
Intrinsic Behavioral	0.81 (0.04)***	0.79 (0.04)***	1.47 (0.08)***	0.95 (0.07)
Family	0.98 (0.07)	1.16 (0.07)*	0.95 (0.06)	1.18 (0.12)
Mentors	1.02 (0.04)	1.04 (0.04)	0.94 (0.03)	1.09 (0.06)
Financial	0.94 (0.05)	0.92 (0.04)*	1.06 (0.05)	1.05 (0.08)
Social Good	1.35 (0.07)***	0.98 (0.04)	0.99 (0.04)	1.11 (0.09)
Community Development	2.38 (0.12)***	1.25 (0.05)***	0.67 (0.03)***	1.00 (0.06)

*p<0.05, **p<0.01, ***p<0.001

DISCUSSION

Our initial proposition in this paper claimed that misalignment between personal values and engineering vocations is the core challenge underlying the common symptoms of low numbers, diversity, and preparedness within engineering. To validate this claim, we hypothesized that EWB-USA members would exhibit personal values that (1) were similar to non-member engineers in specific ways that exemplified engineering values ('I am an Engineer'), and (2) were broader than non-member engineers in specific ways that were uncommon among most engineers ('I am an Engineer AND'). In the following discussion, the results from the two methods are discussed together, organized first by similarities and then by differences.

'I am an Engineer'

The relative frequencies in the qualitative phase showed that both members and non-members mentioned intrinsic motivations to study engineering frequently. The questionnaire had similar results—that intrinsic interest in engineering was more strongly associated with one's engineering discipline rather than EWB-USA membership. Together, these results support that EWB-USA engineers are as intrinsically interested in engineering as other engineers, which EVT and SCCT say are key values influencing vocational choice (Eccles 1994; Lent et al. 1994).

Another way in which EWB-USA engineers were similar to non-members was in their rejection of the engineering stereotype. Both groups more frequently denied than accepted identification with the typical engineer citing the stereotype as outdated or incorrect. Although EWB-USA members were more expressive in their denial than non-members, the similar emphasis on a more positive image of an engineer indicated their shared value of the profession.

In addition, the results from the regression analyses on personality traits showed that EWB-USA members and non-members had similar personality traits as those that have been attributed to engineers (Silver and Malone 1993)—conscientiousness (being dependable, careful, organized, etc.) and emotional stability (being calm and secure). The lack of significant differences between the two groups for both of these personality traits further indicated that EWB-USA members were similar to other engineers.

'I am an Engineer AND'

Results also indicated clear ways in which EWB-USA members held broader personal values than non-members. Both the qualitative and quantitative data found that EWB-USA members were motivated to study engineering by a desire for social good or community development work more than non-members. In applying EVT to study women in engineering, Eccles (2007) has argued that women are less drawn to engineering due to their social and altruistic values. Although our results found that more women participate in EWB-USA than most engineering settings, our results also challenged the idea that *all* women hold social or altruistic values. We found that female EWB-USA members more frequently mentioned social good and EWB-type work as motivations for engineering than males in EWB-USA *and* non-EWB females. We also found that SWE members, with nearly 90% females, did not display higher social good or community development motivations than non-SWE members in regression analyses, even when the control for gender was removed. These results indicate that EWB-USA members' social and altruistic motivations may not be solely attributable to gender.

Regression analyses for personality traits showed that EWB-USA members not only had similar engineering traits of conscientiousness and emotional stability as non-members, but that they also had two significantly higher personality traits—agreeableness (being friendly, trusting, flexible, etc.) and openness to experiences (being curious, cultured, broad-minded, etc.)—than non-EWB members. These traits aligned with many EWB-USA interview and focus group participants who indicated broader interests than non-members including music, poetry, travelling, other cultures and languages, philosophy, etc. As the focus group excerpt showed, "broader" was a key term members used to describe themselves and their attraction to engineering and to EWB-USA.

Implications

Together, the results resound a consistent declaration from EWB-USA members: I am an engineer AND—*and* humanitarian, *and* am passionate about social justice, *and* a politician, *and* have a heart for the world, *and* have vast interests, etc. We found that EWB-USA members held values similar to non-members and which aligned with the engineering field; these engineers truly want to be engineers. However, we also found that EWB-USA members had broader values than other engineers which did not align with common views of the engineering field. SCCT and EVT clearly indicate that alignment between personal values and a vocation are key for career choices. This helps explain why engineers with different values and demographics are congregating in socially engaged engineering experiences such as EWB-USA, and it suggests that without such outlets, EWB-USA members may have difficulty seeing their alignment with the engineering field.

Seeing both engineering and broader values among engineers engaged with EWB-USA should alert the engineering field to a new type of engineer interested in a shift of the engineering vocation. We agree with Riley (2008 p. 34) who argues that, "the profession itself and its meaning in society can and do change, reminding us that we can shape what engineering is in order to make it more responsive to social justice concerns." Rather than attempt to mold these engineers into a stereotype as has been done in the past, we recommend that the field heed the recommendations from Riley and others (Eisenhart et al. 1998; Lucena 2005) and remove the biases within engineering that prevent its alignment with a broader group of people. We believe that alignment is the core issue, which, when addressed, can help to alleviate the lagging numbers, diversity, and preparedness among engineers, as has been witnessed within EWB-USA.

CONCLUSION

In this paper, we have argued that the major concerns plaguing engineering are symptoms of a larger problem of misalignment between personal values and vocational expression of those values. Theory supports that this alignment is a key factor for choosing a vocation, and that the historical misalignment between females' values and engineering in particular have led to their plateaued participation. At the same time there has been a rise in socially engaged engineering programs and organizations calling for the inclusion of social and human-centered components in engineering. Within these programs and organizations, females, minorities, and broadly minded engineers have flourished, seemingly reducing engineering's symptoms.

Our findings have shown that engineers involved in one particular socially engaged engineering organization, EWB-USA, have personal values that both align with engineering values *and* that show broader interests and motivations. In particular, EWB-USA members and non-members showed equivalent intrinsic motivations to study engineering, rejection of the engineering stereotype, and common engineering personality traits of conscientiousness and emotional stability. At the same time, EWB-USA members showed that, compared to non-members, a desire to do good and help others was an important motivator to study engineering, that they had a wider variety of interests, and that they had personality traits less common to engineers—agreeableness and openness to new experiences.

These results indicate that there is a group of engineers who value both engineering AND social engagement, and they should caution the engineering field to reflect on who it includes and excludes with its current values. A misalignment of personal and vocational values may be the cause of the persistent low numbers, diversity, and preparedness in engineering, but, like any good doctor, the engineering field should target the root cause rather than these symptoms themselves. We recommend that the field continues to investigate this potential root cause identified in this paper to move away from targeting the symptoms and towards rethinking the values of the profession in ways that better align with a broader group of people. With the growth of socially engaged engineering opportunities and with the maturing of the Millennial Generation that values helping others and creating change, creating alignment includes better incorporating socially engaged engineering throughout schools, curricula, and vocations. Without these changes, the underlying issue and its symptoms will likely continue to persist.

Limitations and Future Work

This study focused on EWB-USA members due to its prominence as a socially engaged engineering activity. The use of multiple methods and a large number of participants strengthen the findings; however, the results may be limited to EWB-USA specifically rather than socially engaged engineers in general. Future work could expand the study for a broader range of socially engaged engineering initiatives, including a random sampling technique, to make the findings more generalizable. In addition, the study focused on engineers within the US specifically. Future work could extend this study to international socially engaged engineering activities to test the findings across cultures. This work focused on EWB-*USA*, and any implications derived from the findings should be focused within the US specifically.

This study was also limited in its focus on two quantitative measures of personal values. Pre-established scales for self-reported personality traits and motivations were used for simplicity, but additional and more objective measures of personal values, particularly the additional values found in literature such as self-efficacy, may provide more insight into EWB-USA members. The focus on personal values highlights another limitation of this study. That is, the focus on the alignment of personal values and vocation ignores barriers to vocational entry, which are especially prevalent among female and minority engineers. Barriers such as a hostile work environment, isolation, and extreme work environments are known to divert many from engineering (Hewlett et al. 2008), even when they have personal values that align with engineering. This study does not address such barriers.

Our work focuses on identifying unique values within EWB-USA members that contribute to their personal alignment with socially engaged engineering fields. Although this study cannot make causal claims, our questionnaire data analyses address the assumptions necessary to move towards a causal explanation of personal values influencing EWB-USA membership (Agresti and Finlay 1997). Future studies can expand this work by further exploring a possible causal relationship. In addition, this study stops short of exploring where these unique engineers can study and work and what tensions arise in their efforts to do so. Future work should continue to follow EWB-USA members along their engineering pathways to determine how their unique personal values contribute to or hinder their careers, and it could better expose the pathways for those who looking for places to fulfill "*the other part of me that isn't an engineer*."

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CHAPTER 3

Professional Advantage: A Mixed-methods Comparison of Technical and Professional Skills among Engineers Involved and Uninvolved in Engineering Service

Abstract

Background – Engineers must obtain more professional skills for the changing profession; however, fitting these skills into already crowded curricula is difficult. Engineering service activities such as Engineers Without Borders (EWB-USA) may provide opportunities to gain such skills; however prior research about learning outcomes from such activities have been primarily small-scale or anecdotal. This research aims to analyze the learning outcomes of such engineering service activities.

Purpose/Hypothesis – We aim to understand whether or not there are differences in learning outcomes between EWB-USA and non-EWB-USA engineers as a case of engineering service participation. Specifically, do the two groups learn and experience different technical and professional skills in their engineering activities?

Design/Method – We used a sequential mixed-method approach that began with interviews and focus groups with 165 students and practitioners throughout the country and ended with a survey of over 2,500 student and practicing engineers both involved and not involved with EWB-USA. Analyses included variable-oriented qualitative analysis and multiple linear regression models.

Results – Quantitative results showed that EWB-USA members and non-members had comparable technical skills, and that EWB-USA members had significantly higher professional skills, even when controlling for gender, age, and GPA. Qualitative results supported that higher PS

can be partially attributed to the realistic, complex, and contextualized learning experiences that come from engineering service activities.

Conclusions – Engineers engaged with EWB-USA and other engineering service gain strong professional engineering skills that do not compromise their technical skills. Thus, engineering service may help create the type of engineers the field needs to address pressing global challenges.

INTRODUCTION

Engineers have been valued for their technical expertise for centuries. This expertise has often distinguished engineers' role as civil servants designing and creating for the needs of humanity. However, as the global population increases, the complexities facing engineers are also increasing (e.g., UNESCO 2010; United Nations 2013). In an effort to equip engineers to face such challenges, engineers are being asked to expand their skill set to address sociotechnical issues (National Academy of Engineering (NAE) 2004); however, an image of engineers as organizers of "both the physical and the human world" has yet to be widely endorsed (Stevens et al. 2014 p. 122, original italics).

Within the last two decades, engineering education has attempted to mitigate the sociotechnical divide. Most noticeably, ABET, the accreditation board for US-based engineering programs, recognized the importance of creating flexible engineers with a wide variety of skills, and thus developed new learning outcomes in 2000, known as 3a-k (ABET 2011; Lucena 2005). A subset of ABET's eleven learning outcomes—often referred to as "professional skills" (Shuman et al. 2005)—have been particularly challenging for educators to incorporate in already overcrowded curricula (Olds et al. 2005; Sheppard et al. 2008). Educators and researchers have experimented with different ways to meet such outcomes, and many have advocated for non-traditional educational methods including service-learning activities, praising their potential for aiding engineers' professional skills (Bielefeldt et al. 2010; Shuman et al. 2005).

Despite the growing emphasis to teach engineers professional skills through service-based engineering, existing research to date has been anecdotal or small-scale and requires additional study. Therefore, to address this need, this research analyzed data collected from engineers across the US involved with, and not involved with one of the largest and most prevalent engineering service organizations in the US—Engineers Without Borders (EWB-USA)—as a case of engineering service participation. Using mixed methods, we compared learning experiences and perceptions of technical and professional skills between engineers involved and not involved with the organization and explored the generalizability of these results to other engineering service participants.

Background

This section describes the engineering service organization studied, EWB-USA, and its developing role in the engineering profession and in engineering education and reviews previous studies assessing learning outcomes among engineering service activities. The section concludes by presenting the research framework and questions.

EWB-USA in the engineering profession

Engineering service programs, organizations, and opportunities are growing, with a particular surge over the last two decades (Muñoz and Mitcham 2012; Schneider et al. 2009; Shuman et al. 2005). One such engineering service program, Engineers Without Borders (EWB), was officially established in the United States in 2002. Since then, EWB-USA has grown to over 14,700 members working in 47 countries and has become a prominent name among engineering service organizations with 286 university-based student chapters and city-based professional chapters across the US (EWB-USA 2014). EWB-USA's mission claims, "EWB-USA is a nonprofit humanitarian organization established to support community-driven development programs worldwide through partnerships that design and implement sustainable engineering projects, while creating transformative experiences that enrich global perspectives and create responsible leaders" (EWB-USA 2014). In a report by the UN's Educational, Scientific and Cultural Organization (UNESCO), Andrew Lamb, the Chief Executive of EWB-UK, wrote that "EWB groups have been effective at alerting the engineering profession to the challenge of international development" and "alerting the international development community to the importance of engineering once again" (Lamb 2010 p. 161). EWB-USA has helped highlight the value of engineering in solving global challenges and increased excitement about the engineering profession.

EWB programs have also been found to be a powerful recruitment tool for the engineering profession, drawing large numbers of participants (Amadei and Sandekian 2010; Budny and Gradoville 2011; Moskal et al. 2008; Paterson and Fuchs 2007). This has been particularly true among women and minorities (Bielefeldt 2006), with EWB-USA experiencing female participation over twice the national average of women in engineering (Amadei and Sandekian 2010; National Science Foundation (NSF) 2013). Such programs motivate engineers by offering tangible application of their skills in service to humanity, which are especially in line with women's altruistic motivations and interests (Faulkner 2007; Schreuders et al. 2009). Although the field should be mindful of unintended consequences of such activities (Riley 2008; Schneider et al. 2009), the continued growth of such programs could be substantial, as the UNESCO report noted, "[A] new interdisciplinary thrust of engineering can be expected to emerge, what can perhaps be called engineering for development. …Training a sufficient number of engineering professionals focused on development should become a high priority..." (Bugliarello 2010 p. 58). A new engineering discipline would require additional engineers; the diverse recruitment among engineering service opportunities may provide the needed professionals.

EWB-USA in engineering education

In addition to recruiting a large number of diverse engineers, engineering service experiences can also help prepare and train engineers to broaden their technical knowledge. Although engineering practice largely involves both technical and social components, this image of the field is not yet widely supported (Stevens et al. 2014). In Educating the Engineer of 2020 (NAE 2005), Katehi (2005) writes that, among many attributes, future engineers will need to be broad based, flexible to other ways of life, understanding of differences, attune to societal problems, and aware of the socioeconomic landscapes around the globe:

> *Although the future is unpredictable, the skills required for engineers to be successful are well known. And one thing is for sure—the future will be global. Neither the United States nor any other developed country will be able to ignore global issues. Addressing poverty and health care delivery on a global scale and accepting social responsibility will not be matters of philanthropy but of survival.* (Katehi 2005 p. 153)

Some evidence suggests that engineering service activities are helping to broaden engineering education along these lines. For example, educational benefits that come from such opportunities are described in a case study of an EWB-USA student chapter by Budny and Gradoville (2011). They summarize the benefits of international service projects as multidimensional in which the project experience simulates "the real-world implementation experience"; the service component highlights "the importance of understanding customer needs" and "the concept of engineering as a tool for helping society"; and the international aspect challenges "the most basic assumptions in our daily lives" (p. 100). The combined effects from international service projects seemingly multiply the educational impact of such experiences in ways that traditional coursework learning do not.

In efforts to formalize the educational value of EWB-USA, many have attempted to align outcomes from EWB-USA experiences with ABET's learning outcomes. For example, Amadei and Sandekian (2010) summarized a list of EWB project benefits for students, indicating that many matched the 11 ABET criteria. These included such items as "teach[ing] the students how to interact with different cultures and thinking "outside the box' with limited tools" (p.88). Jaeger and LaRochelle (2009) took a more direct approach, specifically mapping the benefits of EWB-USA involvement to each of the ABET outcomes. Other researchers used Shuman et al.'s (2005) distinctions of five "technical" outcomes (a, b, c, e, and k) and six "professional" outcomes (d, f, g, h, i, and j; see Table 3-1), which were similar to distinctions by the International Journal of Service Learning in Engineering (IJSLE 2012), finding that EWB-USA targets professional outcomes in particular (Bielefeldt et al. 2010; Budny and Gradoville 2011; Shuman et al. 2005). Although many have acknowledged the educational benefits of EWB-USA experiences, particularly for professional skills, existing work has been either anecdotal (e.g., Amadei and Sandekian 2010; Bourn and Neal 2008; UNESCO 2010) or small-scale (e.g., Budny and Gradoville 2011; Jaeger and LaRochelle 2009; Zornes and Kaminsky 2009). Therefore, there is a need for large-scale empirical evidence for the learning outcomes associated with EWB-USA involvement as a case of engineering service participation.

Previous Studies of ABET Outcomes

There are challenges associated with defining, measuring, and achieving certain ABET outcomes, particularly the more nebulous professional skills (Besterfield-Sacre et al. 2000; Shuman et al. 2005). We review previous studies that analyzed the effects of serving learning on ABET outcomes to situate our work. Carberry (2010) surveyed engineering students engaged with learning through service (LTS), including EWB-USA members, to compare student's perceived learning outcomes from coursework and LTS experiences. Carberry's outcomes were based on ABET's 11 a-k outcomes as well as four additional professional learning outcomes (referred to as l, m, n and o), found extensively in the literature by the Center for the Advancement of Scholarship on Engineering Education (CASEE 2005). Table 3-1 below lists the combined fifteen learning outcomes. Carberry (2010) found that LTS students claimed to learn professional skills from their LTS experiences more than from their coursework.

Table 3-1: ABET and CASEE* learning outcomes separated by technical and professional outcomes

Technical Outcomes:
(a) an ability to apply knowledge of mathematics, science, and engineering,
(b) an ability to design and conduct experiments, as well as to analyze and interpret data,
(c) an ability to design a system, component, or process to meet desired needs,
(e) an ability to identify, formulate, and solve engineering problems,
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice,
Professional Outcomes:
(d) an ability to function on multidisciplinary teams,
(f) an understanding of professional and ethical responsibility,
(g) an ability to communicate effectively,
(h) the broad education necessary to understand the impact of engineering solutions in a global & societal context,
(i) a recognition of the need for, and ability to engage in, lifelong learning,
(j) a knowledge of contemporary issues;
(l)* an ability to manage a project, including a familiarity with business, market-related, and financial matters,
(m)* a multidisciplinary systems perspective,
(n)* an understanding of and appreciation for the diversity of students, faculty, staff, colleagues, and customers,
(o)* a strong work ethic.

Note: Distinctions of technical and professional skills were based off Shuman et al. (2005).

Others have taken a qualitative approach to study engineering service outcomes. For example, Mostafavi et al. (2013) used a case study approach to investigate ABET outcomes and American Society of Civil Engineering's Body of Knowledge outcomes (ASCE 2008) among students engaged with Purdue's Engineering Projects in Community Service (EPICS) program—an engineering service program similar to EWB-USA (Bielefeldt et al. 2009). Through qualitative data and analysis aligning students' experiences with learning outcomes, the team found two main outcomes of the EPICS experience—"designing in a real-world context" and "critical and reflective thinking" (p.8)—both of which helped to integrate students' technical and professional skills. Finally, in our own previous work (Litchfield and Javernick-Will 2014) we analyzed open-ended responses of EWB-USA members' gains from their participation and found that, in addition to gaining engineering experience and application, members frequently mentioned broader gains including a global perspective, project management skills, and awareness.

Despite the previous research on learning outcomes associated with engineering service activities, each of these three previous studies lacked a comparison group of non-LTS or non-EWB-USA members. To address this need, this study builds upon previous work to study learning outcomes from engineering service, but also uses a comparison group of engineers who are not involved in EWB-USA or engineering service. In addition, this work uses large-scale, mixed-methods data to respond to calls for more robust understanding of the educational impacts of service learning activities such as EWB-USA (Bielefeldt et al. 2010; Mostafavi et al. 2013).

RESEARCH FRAMEWORK AND QUESTIONS

Due to the need for more robust evidence of learning outcomes associated with engineering service, this study is grounded in learning theory. We build on Kolb's experiential learning theory, which claims, "Learning is the process whereby knowledge is created through the transformation of experience" (Kolb 1984 p. 38). Expanded further, this theory views learning as a cyclical process requiring four main steps: concrete experience, reflective observation, abstract conceptualization, and active experimentation. As learners engage in iterations of each of these four steps through their experiences, they produce knowledge and learn. Experiential learning theory is consistent with a definition of learning outcomes where knowledge exists in conjunction with application (Besterfield-Sacre et al. 2000; Olds et al. 2005), which is also in line with ABET's definition (ABET 2011).

Kolb's theory emphasizes learning as cycles of experience and reflection, which influences this study in two important ways. First, this view of learning values learning beyond formal environments (Paterson and Fuchs 2007), which indicates that learning can take place in engineering activities that both do and do not include service. Therefore, to study the values of engineering service activities, this theory reiterates the need for a comparison group with non-service engineering activity experiences. In addition, because experiential learning views learning as continuous and not bounded by formal education, it is important to study engineers across both university and workplace settings to gain a more comprehensive picture of the learning that takes place through engineering service experience.

Our research framework begins with Kolb's learning cycle as the means by which learning takes place (Figure 3-1). The center of the framework shows four sources of engineering learning experiences. What engineers learn about engineering can be attributed primarily to one of these four experiences. To compare the experiences between our populations of interest (EWB-USA members and non-members), we assumed similarities in these populations' background, formal education, and work experiences, which left engineering activities as the primary difference in engineering learning experiences between EWB-USA members and non-members. Although it is impossible to eliminate or control for all possible differences in the two populations, the large data set and the controls within the statistical analyses attempted to mitigate this assumption. Using this framework, we explored differences in learning experiences and outcomes between EWB-USA members and non-members to offer large-scale empirical evidence about technical and professional skills learning in engineering service activities.

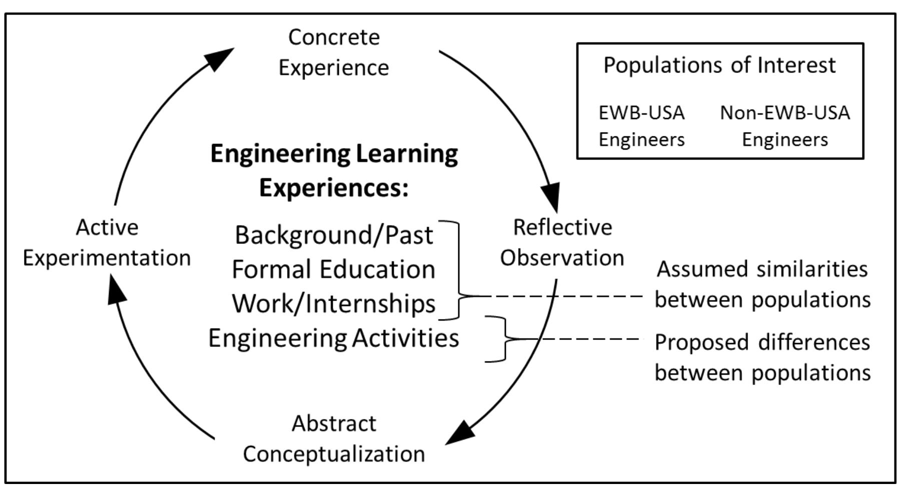

Figure 3-1: Conceptual framework using Kolb's experiential learning theory

We employed an exploratory sequential mixed methods approach (Creswell 2009), which followed accepted practice for engineering education research (Olds et al. 2005). In addition, we took up a critical realist perspective for overall analysis, which allows for multiple, partial yet valid perspectives on one complex reality (Maxwell 2012). This perspective encourages the use of multiple methods and analysis strategies for stronger validity. Thus, in the first phase of this study we used qualitative interviews and focus groups to explore the question, what learning outcomes do EWB-USA members and non-members experience in their engineering activities? And then, upon discovering trends in the qualitative data, the second phase developed a nation-wide questionnaire and used multiple linear regression analyses to test the hypothesis that technical and professional learning outcomes differed between EWB-USA members and non-members when controlling for potentially confounding variables such as gender, age, and GPA.

In the following sections, we first share the qualitative methods followed immediately by the qualitative results. Then, we share the methods employed and results obtained from the questionnaire. The findings from both phases are combined in the discussion.

QUALITATIVE METHODS AND RESULTS

Qualitative Collection and Analysis

The first phase of this research used interviews and focus groups to collect qualitative data to explore the learning outcomes associated with engineering service activities. Beginning in the spring of 2011 and continuing over the course of eighteen months, 165 engineers participated in 27 interviews and 32 focus groups. Table 3-2 summarizes the demographics of the participants, which included 105 EWB-USA members and 60 engineers not involved with EWB-USA; 85 males and 80 females; and 90 engineering students and 75 working engineers. These participants lived in 24 states in the USA and represented 18 different engineering disciplines. Participants were solicited from American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers

(ASME), Society of Women Engineers (SWE), and EWB-USA conferences and chapters. Snowball sampling was also used to find participants with demographics that were missing from our sample, such as working women involved with EWB-USA, who were often difficult to find and schedule time with.

Table 3-2: Demographic breakdown of qualitative research participants

EWB-USA Members 105				Non-EWB-USA Members 60			
Females 51		Males 54		Females 29		Males 31	
Practitioners	Students	Practitioners	Students	Practitioners	Students	Practitioners	Students
14	37	30	24	13	16	18	13

Both focus groups and interviews took place either in person or over the phone with one to two members of the research team. Researchers positioned themselves as university-affiliated researchers uninvolved with EWB-USA or any other professional engineering organization who were interested in improving engineering education. After consent was received by participants in accordance with IRB regulations, interviews and focus groups were audio recorded. For their participation, participants were offered a $10 gift card or snacks and refreshments. Focus groups were either entirely female, entirely male, or mixed gender and were either entirely EWB-USA members or non-members; students and practicing engineers were not combined for data collection primarily due to convenience. Because this was exploratory research, questions were semi-structured following pre-determined themes (Spradley 1979) and allowing for changes as deemed important by the research team. Example questions included, "How do you spend your free time outside of class or work? Are you or were you a member of any professional engineering organizations? What have you gained from being involved with [your organization]? What has or did your involvement meant for your career or education? Have you been involved with community service?" Due to the semi-structured and exploratory nature of this research phase, not all participants shared gains and benefits of their organization or service-based engineering activities.

Interviews lasted about 40 minutes each and focus groups about one hour, which totaled over 36 hours of audio recording. Each file was individually transcribed, cleaned, and uploaded into qualitative coding software, NVivo 10 (QSR International 2013). Two members of the research team discussed the transcripts and coded emergent themes of participants' learning outcomes. Throughout the coding process, a coding dictionary was maintained, as suggested by Miles and Huberman (1994). One team member performed the majority of the coding and another member helped discuss and recode select transcripts, which averaged 95% agreement. Codes were consistent with ABET and CASEE learning outcomes based on the definitions listed in Table 3-1. Any outcomes that did not map to a specific learning outcome were grouped into a "personal outcomes" theme that was then recoded for emergent subthemes such as satisfaction, relationships, confidence, etc. For example, the satisfaction theme included mentions of a specific activity being rewarding, fulfilling, or personally satisfying. To compare findings across cases and groups, we used a variable-oriented analysis approach (Miles and Huberman 1994). Upon final coding, a clustering technique was used to refine the coded data into summaries and representative quotes (Miles and Huberman 1994).

Qualitative Results

Of the 165 participants in the interviews and focus groups, 95% (n=156) discussed outcomes from their engineering activities. The majority of respondents (85%) mentioned personal outcomes from their engineering activities, while 32% of respondents mentioned gains that mapped onto ABET learning outcomes. Those who were not involved with EWB-USA listed a variety of engineering activities including professional engineering organizations (such as SWE, ASCE, ASME, National Society of Black Engineers, Society of Hispanic Professional Engineers, Association of General Contractors, etc.), co-op experiences, organizational competitions, and engineering-based community service, honors programs, and research opportunities. For the purpose of this paper, we focus our analysis on participants' learning outcomes, specifically dividing results by technical and professional skills (abbreviated TS and PS, respectively, as distinguished by Table 3-1). In addition, because purposive and not random sampling was used, no efforts to quantify or statistically analyze the qualitative data were made. Thus, results are presented as general trends.

Technical Skills

EWB-USA members and non-members both mentioned learning TS through their engineering activities. Both groups discussed their activities as places to apply what they were learning in the classroom. For non-EWB-USA members, this was most prevalent among those who participated in design competition teams such as ASCE's steel bridge or ASME's Baja car. Noticeably more EWB-USA members than non-members mentioned outcome c (an ability to design a system, component, or process to meet desired needs), noting learning to understand clients' needs before embarking on a project. In comparison, many of the project-based organizational activities did not report directly to a client. One non-EWB-USA professional member reflected learning this skill through his senior project for which he designed an adobe structure for a small community in central Africa—a project similar to the small-scale, community-based nature of many EWB-USA projects.

Although both groups showed evidence of learning TS through their engineering activities, a major difference between the two groups surfaced regarding the timing of learning these skills. Many non-EWB-USA members spoke about learning to apply their engineering education on their first job or internship rather than in school. One female stated, "*I probably learned more from the technician who operated our [water] treatment systems and just getting out there and… learning about the systems and actually seeing how [to ask] when the systems broke, 'What's wrong, how do we* *fix it?'"* (FNP6)[1]. In contrast, EWB-USA members spoke extensively about their opportunities to apply and use their engineering while in school through EWB-USA participation. This not only increased their learning but also their confidence: *"There's also the project implementation that a lot of people coming out of school don't know about because they've only taken classes. We figured out where the ground water was coming from and we made this … and now we have water here, and so that's pretty cool [to be] 18 or 19 and say you can do that"* (FES16). Although both EWB-USA members and non-members spoke of the benefits of the "real-world" nature of their engineering activities, EWB-USA members stressed the realistic nature of their experiences. Some members even questioned the value of fabricated design competitions in comparison to EWB-USA. This realistic nature of EWB-USA members' experiences contributed to additional confidence, as this male said, *"You gain experience in EWB extremely quickly, and when you do that it already sets in your mind, 'Well I've already been an engineer for six years'"* (MEP10).

Professional Skills

Among the ten PS outcomes, similarities between EWB-USA members and non-members varied. Two PS outcomes that were not common across either group were (i) lifelong learning and (j) knowledge of contemporary issues. Non-members mentioned neither of these outcomes other than what they learned once working. A few EWB-USA members mentioned gaining an appreciation for learning on their own through EWB-USA saying, *"you become more interested in other things and you want to educate yourself in other subjects"* (FEP3). One EWB-USA member mentioned that she was encouraged to apply her engineering *"in a policy setting or sociologic setting*" (FES12) through her involvement with EWB-USA.

The most similar PS between the groups were (d) working in teams, (g) communicating effectively, and (o) having a strong work ethic. Both groups discussed these three outcomes as part

[1] Notation for referencing qualitative participants consists of three letters (F or M for female or male, E or N for EWB-USA member or non-member, and S or P for student or practitioner) followed by a unique number.

of their engineering activities. Those not involved with EWB-USA discussed learning communication skills through a range of experiences such as taking leadership roles in their organizations. In addition, some non-EWB members discussed learning communication skills through having actual clients in engineering service work with organizations such as ASCE, Habitat for Humanity, etc. For example, when speaking about his gains from ASCE community service involvement, this male student said, "*The biggest thing has been communication. I think you can handle the technical part just fine, and you know how to problem solve, but it's hard when the client asks something of you, [and] you have the technical answer, but you have to present it in a way that they'll understand, but you don't want to be misleading*" (MNS6). EWB-USA members also described learning PS through working with real clients on their EWB-USA projects. Other PS outcomes, such as outcomes f (professional ethics and responsibility) and n (diversity appreciation) were discussed by both groups primarily in the context of engineering service opportunities, which highlighted an emerging trend about learning through service activities.

Outcome l (project management, business, and financial skills) was among the most frequently mentioned themes for both groups. Participants stressed how either EWB-USA or project experiences such as ASCE's concrete canoe team helped them learn project management skills including scheduling, finances, and leadership. For example, one EWB student contrasted his EWB-USA experience with his senior project to say that senior project was limited to *"the design and planning aspects"* whereas EWB was much more like a *"real firm"* that had to *"manage all your finances"* and *"know all your funders and deal with your clients"* (MES11). Similarly, one non-EWB-USA male engineering student indicated that the concrete canoe team gave him *"insight in project management, just thinking about completing task A before you complete task B and how everything matches together"* (MNS4). Although both groups mentioned this outcome, the primary difference came from the complexities that the EWB-USA members discussed in their experiences: *"I mean, how else can you graduate from college with multidisciplinary, inter-cultural project management* *experience?"* (MEP11). This male stressed that EWB-USA went beyond just project management skills into "*multidisciplinary, inter-cultural"* skills that came with *"experience."* These words echoed the multidimensional effects of international service projects previously noted by Budny and Gradoville (2011).

The remaining two PS—(h) the broad education necessary to understand the impact of engineering solutions in a global & societal context, and (m) a multidisciplinary systems perspective—further highlighted the complexities that EWB-USA members experienced. Few non-members mentioned learning these skills at all, and those that did mentioned learning them either once *"being hands-on"* on the job or from research experience. For example, a female who had performed research *"helping kids in India who had measles*" said that experience, *"was just kind of the boost that I needed in the midst of the misery of engineering school knowing that what we do is great"* (FNP7). Through research that she viewed as "*helping kids in India*," she saw the impact of her engineering work on a global scale.

EWB-USA members mentioned outcomes h and m regularly, which often overlapped each other. For example, a male said, *"the one thing you quickly learn in EWB is that if you don't take into account local culture and you don't get their buy in, it's a lot easier for your project to fail"* (MEP9). He learned that the engineering solution must be appropriate for its context, which included incorporating multiple perspectives into design. Many others reiterated this outcome stating that EWB-USA experience helped them see that engineering is *"going beyond the technology."* This female student summarized such multidimensional learning well:

> *"EWB offers the opportunity to get outside of [the conventional classroom] and to say here's the problem and how to tackle it, and there's all these other issues surrounding it besides just applying an equation, but you have to consider them. You have to consider the cultural dynamics, you have to consider how the different genders in your community relate to each other, and I think that just makes it all the more fascinating and all the more challenging, but so much more valuable."* (FES12)

Not only did this student learn about *"all these other issues"* such as *"cultural dynamics"* and gender relationships, but she also felt that those other considerations were *"much more valuable"* than her classroom work. Non-EWB-USA-member participants did not speak of learning about the importance of context in their designs, nor did they speak about *"going beyond technology."* In our data, these learning outcomes were unique to those with EWB-USA experience, which suggested the value of EWB-USA experiences for learning certain PS, and more specifically, skills in complex, contextualized systems thinking.

In response to the initial qualitative research question, overall trends from this phase indicated that nearly all of the ABET and CASEE learning outcomes were experienced through engineering activities. It appeared that TS experiences were equivalent between EWB-USA members and non-members, but that EWB-USA members may learn to apply TS earlier in their education. For PS, it appeared that EWB-USA members had more opportunities to experience multiple outcomes through the real-world, contextualized complexities of EWB-USA projects. These findings aligned with a literature review by Prince (2004) that found active, project-based experiences within engineering were unlikely to improve student test scores, but were likely to foster student attitudes and life-long habits. In addition, an initial trend was found that suggested the benefits of engineering service beyond only EWB-USA for learning PS.

QUESTIONNAIRE METHODS AND RESULTS

Questionnaire Data Collection

To further investigate the trends found in the qualitative data, the research team developed a questionnaire to measure learning outcomes. The learning outcomes section of the questionnaire drew items from CASEE's report (2005) in which researchers created 62 items to assess students' perceived abilities for each of the eleven ABET a-k outcomes and their additional four l-o outcomes. Results from their pilot testing at five US-based institutions used factor analyses and intercomponent correlations, in addition to faculty and student focus groups, to help validate their items. Cronbach's alpha estimates were calculated for each of the fifteen outcomes, all but one of which were over 0.70 (for outcome o, α=0.35), indicating strong reliability (Drewery et al. 2006). To decrease the size of our questionnaire, we reduced CASEE's original item list to 45 items keeping two to four items per outcome. All Cronbach's alpha estimates for the new scales were over 0.70 except for outcomes m (α=0.61) and o (α=0.53). The items remained in their original format except for minor edits to make the items applicable to both student and practicing engineers (e.g. changing "classroom" to "work space").

All of the learning outcomes items used Likert-style items, which was consistent with CASEE's original design. Twelve of the fifteen outcomes asked participants to "rate your ability to do the following" on a five-point scale from no to high ability. Outcomes i and n asked participants "to what extent do you/are you" on a four-point scale from not at all to always; and outcome o asked participants "how often" using a four-point scale from almost never to almost always. Self-evaluations to assess skills ideally are paired with independent evaluations (Bielefeldt et al. 2009); however, the complexities of measuring ABET outcomes (Besterfield-Sacre et al. 2000; Shuman et al. 2005) and the increased time and costs associated with such data collection prompted the use of self-reported learning gains. Although self-reported learning gains can be fairly accurate measures of skills (Terenzini et al. 2001), particularly when comparing learning between groups (Prados et al. 2005), this is a limitation of this study.

In January 2014, members of ASCE, ASME, SWE, and EWB-USA received the questionnaire, which was marketed as an NSF funded research in engineering education study. ASCE, ASME, and SWE were selected for a comparable sample of non-EWB-USA engineers. Ideally, a random sample would have been selected from the entire population of US-based engineers; however, because this was not possible, ASCE and ASME represented a sample of engineers who worked in disciplines similar to most EWB-USA projects. In addition, because EWB-USA tends to have a higher percentage of females than the typical engineering setting (Amadei and Sandekian 2010; NSF 2013), SWE members increased the population of women in the non-EWB-USA sample. Soliciting organization members also ensured a sample of non-EWB-USA engineers with organizational experience with which to compare. Due to differences in organizational policies, some organizations solicited their entire US-based membership while others selected a random sample to receive the questionnaire. In total, 118,036 organization members (7% of whom were official EWB-USA members) received a link to the online questionnaire hosted in Qualtrics survey software.

Questionnaire Analysis: Multiple Linear Regression

Questionnaire items about learning outcomes were analyzed using two multiple linear regression models distinguished by differing outcome (dependent) variables—(1) technical skills and (2) professional skills. Both outcome variables were created using the Rasch model (Rasch 1960) which estimates person locations along a uni-dimensional scale of high to low skills. This model uses a probabilistic approach to approximate each participants' location on a continuous scale based on their responses and the responses of the larger sample. The output provides an estimated score and standard deviation for each person. The technical skills variable scored respondents using responses to outcomes a, b, c, e, and k, and the professional skills variable scored respondents using outcomes d, f, g, h, I, j, l, m, n, and o, as distinguished by Shuman et al. (2005) (see Table 3-1). Construct Map software (UC Berkeley 2013) was used to produce the scale scores which were then standardized for ease of interpretation. Estimated reliability was high for both item sets (e.g., Cronbach's alpha estimates for TS and PS were 0.95 and 0.94, respectively). Scale scores were uploaded with the remaining questionnaire data into Stata 13 software for regression analyses.

Both TS and PS models used the same explanatory (independent) variables. The main explanatory variable of interest was a categorical variable for service participation with three mutually exclusive categories: EWB-USA members, non-EWB engineering service participants, and participants in neither EWB nor engineering service. EWB-USA membership was defined by participants who selected official or unofficial (meaning unregistered) involvement with EWB-USA. Engineering service participation was comprised of those who were not involved with EWB-USA and who answered positively about their participation "in an engineering service curriculum, organization, or program similar to, but NOT including, Engineers Without Borders-USA." Respondents who were not in EWB-USA and did not indicate engineering service participation were grouped into a non-EWB, non-service category, which served as the reference category in the regression analyses. The use of these three categories allowed us to test whether or not EWB-USA membership was a distinct category from other engineering service participation.

Other response variables included a dichotomous variable for being female, a continuous variable for age created by subtracting the year 2014 from year of birth, and a continuous variable for estimated undergraduate engineering GPA using the mean scores from the categorical responses. These three control variables were used because results from the descriptive statistics indicated significant differences between EWB-USA members and non-members, which would confound the results (see Table 3-3). A cutoff of alpha equal to or less than 0.05 was used to test for significance.

Questionnaire Results: Demographics

After leaving the questionnaire active for one month, 2,896 people responded to the questionnaire (a 2.5% response rate). Despite the low response rate, there was no reason to believe that the population who took the survey varied significantly from the population who did not take the survey; therefore, self-selection bias was not a concern. Because the research bounded the study on EWB-USA and US-based engineering learning outcomes, we removed respondents who indicated that they either were not US citizens or did not have an engineering degree. Anyone with missing data for gender, age, GPA, skills estimates, or service participation was dropped from analysis.

The final data set held 2,518 respondents—630 EWB-USA members (25%), 347 engineering service participants, and 1,541 non-EWB, non-service participants. Within this sample, 29% were students and 25% were females, which were comparable demographics to the overall survey population (31% students and 28% females). Because all of the organizations' membership databases did not include additional demographic information, our comparisons between the sample and population characteristics were limited to gender and student or professional status. Across the other three organizations, 46% were ASCE members, 46% were ASME members, and 13% were SWE members (participants were often involved with multiple organizations). Compared with the survey population, with 7% EWB-USA members, 13% ASCE members, 59% ASME members, and 22% SWE members, the sample population was more evenly divided between the organizations.

Descriptive statistics for demographic information and skill estimates were calculated for the total respondent population as well as each of the three service participation categories (Table 3-3). Statistical pairwise tests of comparison were run between groups based on the type of demographic data. Percentages of females were compared with chi-square tests of proportions, which was significantly higher for EWB-USA members than the other two categories. Age was positively skewed because respondents were no less than 18 years old, the average age to begin college, and GPA was negatively skewed, which is typical of GPA scores; therefore, comparisons of medians using Wilcoxon-Mann-Whitney tests were used on age and GPA. EWB-USA members had a higher GPA and were younger than non-members. Because TS and PS scores were standardized, these variables were normally distributed, and they were compared with one-tailed t-tests. Although significant differences were found between the three categories, these results did not account for demographic differences, which were controlled for in regression analyses.

Table 3-3: Demographic information for total respondents, EWB-USA members, service participants, and non-EWB, non-service participants

	Total Respondents n=2,518	EWB-USA Members n=630	Non-EWB Service n=347	Non-EWB, Non-service n=1,541
% Female	25.2%	37.5% [ab]	22.8% [c]	20.7% [c]
Median Age (range)	39 (18-95)	28 (18-91) [ab]	40 (19-88) [c]	43 (19-95) [c]
Median GPA (range)	3.3 (1.05-3.95)	3.3 (1.05-3.95) [b]	3.3 (1.05-3.95)	3.3 (1.05-3.95) [c]
Mean std. TS score (std. dev.)	0.004 (0.99)	-0.09 (0.94) [ab]	0.14 (1.02) [bc]	0.01 (1.00) [ac]
Mean std. PS score (std. dev.)	0.002 (1.00)	0.10 (1.00) [b]	0.20 (1.04) [b]	-0.08 (0.98) [ac]

Note: significance means p<0.05; a=significantly different from non-EWB service; b=significantly different from non-EWB, non-service; c=significantly different from EWB-USA members

Questionnaire Results: Regression Models

Results from the multiple linear regression models present regression coefficients with standard deviations in parentheses and significance levels indicated by asterisks (Table 3-4). For the TS model, EWB-USA membership was not related to perceived TS scores whereas engineering service was significantly related to an increase in perceived TS ($p<0.05$). The average difference in TS scores was 0.13 standard deviations higher for those who had participated in service than for those who had not participated in EWB-USA or engineering service controlling for gender, age, and GPA. Due to our limited understanding about the engineering service participation, we cannot say why there was a difference in perceived TS between EWB-USA membership and service participation. This finding requires further research. Gender, age, and GPA were significant controls, where being female was associated with lower perceptions of TS, and increased age and GPA were associated with higher perceptions of TS.

For PS, EWB-USA membership and engineering service participation were highly significantly related to higher perceived PS skills ($p<0.001$). The average differences in perceived PS between those involved and not involved with EWB-USA and those involved and not involved with engineering service were 0.25 and 0.29 standard deviations, respectively, controlling for all other variables. There were no significant differences in PS between EWB-USA membership and engineering service categories controlling for age, gender, and GPA. The effect sizes for EWB-USA membership and engineering service for PS were over twice the effect sizes of TS showing a larger difference in PS than TS for those participating in EWB-USA or engineering service. Being female, being older, and having a higher GPA were all significantly related to higher PS.

Table 3-4: Results from multiple linear regression models for technical and professional skills

Variable	Technical Skills (TS)	Professional Skills (PS)
EWB-USA Membership	-0.02(0.05)	0.25(0.05)***
Non-EWB Engineering Service	0.13(0.06)*	0.29(0.06)***
Female	-0.12(0.05)*	0.15(0.06)**
Age	0.01(0.001)***	0.01(0.001)***
GPA	0.37(0.04)***	0.15(0.04)***
Constant	-1.62(0.16)***	-1.14(0.16)***

*Note: Coefficient (standard deviation); *p<0.05, **p<0.01, ***p<0.001*

Additional analyses were run to check for other possible explanations of the findings (results not shown). To check whether or not findings were associated with organizational membership in general, a dichotomous variable for participation in each of the three other solicited organizations (ASCE, ASME, and SWE) were added into the models. Except for higher perceived TS among ASME members, no statistical differences were found among the other organizations, and no changes in significant findings appeared from the models shown in Table 3-4. In other analyses, a categorical variable for level of organizational participation was added based on respondents' maximum level of participation in any of the listed organizations or in another professional engineering organization: no participation, limited participation, moderate participation, or extensive participation. No participation was the reference category, and three dummy variables were created for the remaining categories. All three categories were significant in both TS and PS models, which indicated the value of higher participation in any of the organizations studied. In addition, coefficients for EWB-USA membership and engineering service in both TS and PS models decreased, where coefficients for EWB-USA membership decreased more than those for engineering service. These analyses indicated that higher levels of organizational participation may be part of what contributed to EWB-USA members' additional skill development.

Overall, these results suggested that engineering service was a more compelling comparison group than solely EWB-USA membership, which made sense in light of the many similar engineering service activities available, and that greater participation in engineering service groups was associated with higher perceived skills, particularly PS. These results, combined with trends from the qualitative phase, are discussed further below.

DISCUSSION

Similarities in Technical Skills

Both the qualitative and quantitative results suggested that EWB-USA members and non-members have nearly equivalent TS. Experiences "*outside of the classroom*" or "*solidify[ing] what I was learning in the classroom"* were common ways that both groups reflected upon learning TS through their engineering activities. Results from the regression models showed that TS abilities between the two groups were statistically equivalent, and that engineering service was related to higher perceptions of TS, although the reasons for this difference merit further exploration. The statistical findings agreed with the qualitative data in which experiences learning TS were mentioned by both EWB-USA members and non-members, although EWB-USA members shared specifically about TS gained from the realistic nature of their projects.

EWB-USA participants in the qualitative phase also discussed confidence in their TS at earlier stages of their education than other engineers. To confirm this finding in the quantitative data, interaction effects between EWB membership and age and between engineering service and age were added into TS and PS models, and no significant effects were found. The lack of quantitative evidence for the qualitative finding suggested that earlier TS development among EWB-USA members was not widespread, or it uncovered limitations of the focus groups and interviews. Because the interviews and focus groups focused on learning through engineering activities without including learning within formal education or work activities, the qualitative data may have missed valuable TS learning experiences. Further research is needed to understand this difference; however, the results clearly indicated that EWB-USA and engineering service participants did not lag in their perceived TS compared with other engineers.

Differences in Professional Skills

The combined results for PS showed more differences than those for TS. Although both members and non-members mentioned learning certain PS such as teamwork, project management, and communication skills through their engineering activities, EWB-USA members spoke extensively about the complex nature of their "real world" experiences that grew their PS. In addition, a few non-EWB members with engineering service experience discussed the value of working in realistic environments. Results from the questionnaire confirmed that EWB-USA members perceived their PS to be significantly higher than engineers not participating in engineering service, even after controlling for demographic differences, and the same finding emerged among engineering service participants.

All research is challenged to prove causality; however, our conceptual framework and mixed-method approach help form an argument as to why EWB-USA, and engineering service more broadly, may be important contributors to increased PS. According to Kolb (1984), learning happens over cycles of experience, reflection, conceptualization, and experimentation. In the exploratory qualitative phase, both members and non-members displayed this type of learning through their extra-curricular experiences. For example, an older working female reflected back on her learning experiences in a professional construction organization she participated in during her *"late twenties"* saying that, *"When you have to get up a couple times a year in front of people two or three hundred people it can be very intimidating,"* but her leadership role in the organization, *"really helped me with my public speaking, especially in meetings. In all these senior meetings now it's like, pshh, only 20 people"* (FNP10). She had an experience public speaking, gained confidence, and then acted again with more confidence, which followed Kolb's learning cycle.

Similarly, a working male demonstrated this learning cycle when he spoke about applying what he learned from EWB-USA as a student to his career in wind energy:

> *[My company] wanted to put a wind farm in this community in a mountainous region, and I said, 'Well, as long as we're here can we sit down with the mayor or some of the local officials?' And I'm applying EWB style community development. ...We're sitting in Mayor's living room having a chat about what he thinks about renewable energy and economic benefits to his community, because that's what we should do if we're going to do projects in Honduras, and I'm speaking Spanish and asking questions that I've asked before to indigenous folks in remote areas, and that's a whole different mindset especially for a company that's looking to do to work in different cultures.* (MEP11)

This extended example showed how this engineer took *"community development"* concepts he learned previously with *"indigenous folks in remote areas,"* realized that they were appropriate and important in this new context (*"that's what we should do…"*), and applied them to his new situation at work. He went on to credit his EWB experience with preparing him for this work, saying, "*Just plain and simple, my suburban Midwestern up-bringing would not, in it of itself, have made me very well equipped to hang out with the president of Honduras"* (MEP11).

Both examples demonstrated instances of engineers learning PS through their engineering activities; however, as was typical among the qualitative data, EWB-USA members described additional complexities that created extended learning opportunities. The qualitative results support a causal argument for the reasons EWB-USA members may have higher PS. EWB-USA members find that, *"there's a whole new set of problems you get to deal with"* on their projects that make them think in *"a whole different mindset"* (MES12) for their engineering solutions that *"gets you more experience with stuff other than just the technical"* (MEP5). These complexities in a real-world setting where, *"you have everything that you're going to have in a real-world job-type situation"* (FES13) appear to be key to their additional PS learning, which echoes recommendations to embed technical competencies into contextualized professional practice to address ABET outcomes (Passow 2012).

The framework (Figure 3-1) and the mixed-methods approach form a strong argument that EWB-USA participation, particularly a high-level of participation, aids members' professional skills due to their additional experiences with realistic, contextualized, and complex engineering projects. In addition, the results suggest that the findings are generalizable to engineering service participation that extend beyond EWB-USA. Kolb's experiential learning theory shows why engagement in engineering activities contributes to learning engineering skills, and, by assuming that engineers in our study had comparable engineering experiences in their backgrounds, academics, and work, we highlighted differences in learning experiences and outcomes through engineering activities. This assumption was mitigated through the use of two separate, large and geographically spread data samples and through the use of statistical controls such as age, gender, and GPA. Further research should continue to investigate the extent of the causal relationships and generalizability of results mentioned in this discussion; however, this research provides compelling evidence that engineering service activities contribute to increased PS.

Beyond ABET Learning Outcomes

Results from this study also indicated benefits of engineering service beyond ABET's learning outcomes. During the coding process, alignment between learning experiences and a specific learning outcome was not always straightforward. As the qualitative results demonstrated, some outcomes overlapped, particularly outcomes h and m, and particularly among EWB-USA members. These participants highlighted their complex contextualized design challenges, which pushed them to incorporate cultural, gender, social, economic, and political factors from a holistic perspective into multiple aspects of their projects. These experiences went beyond specific ABET learning outcomes and fulfilled calls for producing engineers with abilities to integrate the technical, social, and ethical dimensions of their work (Sheppard et al. 2008). Our study found that many PS could be achieved in engineering activities other than EWB-USA; however, the depth of the hands-on experiences in complex, contextualized, international problem solving performed for a real client connected multiple PS for those involved with EWB-USA and, in some cases, other engineering service opportunities.

EWB-USA members also showed extensive evidence of personal outcomes from their engineering activities, particularly in the theme of "personal awareness." For example, one working engineer said that his biggest gain from his EWB-USA experience was *"the amount of thinking it makes you do when you are at the community, like if what we're doing is truly right, is this the right way to approach it?"* (MEP12). Another member said that *"EWB is a stepping stone to actually figuring out what I want to do, how I can be happy making an impact and making a difference"* (FES12). In these examples, EWB-USA experience not only helped members with ethical considerations (outcome f) but also with considerations of personal values and future careers in ways that no participant involved in other engineering activities mentioned. The personal outcomes of such experiences should not be overlooked just because they do not map onto a specific learning outcome, and they merit further study. In their study on how engineering students differed from non-engineers, Lichtenstein et al. (2010) concluded that the demands of their extra workload limited engineering students' participation in enriching educational experiences that allow for personal development. The authors wondered if engineers were being forced to choose between gaining practical skills or personal development, and they requested that the engineering community consider the effects of such a choice. In our study, members of EWB-USA appeared to have access to personal development opportunities that complemented learning practical engineering skills. Encouraging participation in engineering service activities such as EWB-USA could help reduce the tension Lichtenstein and colleagues (2010) found.

Findings from this research also began to address issues of gender differences within engineering. Previous research has shown female engineers to rate themselves lower in measures of technical skills than males even when a new service-learning curriculum aided female's growth in technical knowledge (Lathem et al. 2011), and it has highlighted females' strength in the social aspects of engineering (Faulkner 2007). Results from the regression analyses indicated that females perceived themselves to have lower TS and higher PS than males controlling for all other variables. These results followed the previous literature, and suggested that engagement with EWB-USA, or engineering service more broadly, aligns with women's engineering strengths. Further research is needed to investigate if the inclusion of more professional or social skills is part of women's increased attraction to engineering service activities.

CONCLUSION

Existing knowledge of the benefits of engineering service experience for engineers' learning has been either discussion-based, small-scale, or without a comparison group. This research provides the first large-scale empirical study on EWB-USA members' and non-members' technical and professional skills as a case of learning through engineering service activity. Using both qualitative and quantitative methods, we found that EWB-USA members showed similar technical skills and more broad professional skills than their non-member peers. In addition, results were similar for respondents who were engaged with engineering service beyond solely EWB-USA. Outcomes highlighting the complexities of engineering such as those understanding the impact and context of designs (h) and taking a multidisciplinary systems' perspective (m) were particularly common among EWB-USA participants, and experiences with these challenging outcomes promoted learning in areas that other engineers did not appear to experience as frequently. These experiences appear to contribute to EWB-USA members' higher confidence and/or perceptions about their own professional skills without compromising their technical skills.

Limitations & Future Work

Future work to aid the generalizability of these findings should be considered in light of this study's limitations. The limited demographic data available about the questionnaire population and its low response rate encourage replication of this study among additional populations of engineers. As mentioned, this research used self-reported measures of abilities as indicators of learning outcomes. More rigorous assessments of outcomes could be used to further confirm these findings (Bielefeldt et al. 2009). Regression analyses could not control for all possible demographic differences, therefore, assumptions were made about the similarities between populations based on the research framework (Figure 3-1); however, other differences should be considered, such as backgrounds and personality traits. Future work is investigating these topics. Although age was intended to mitigate differences between student and practitioner participants, their grouping is a limitation that could mask valuable differences and should be explored further. Future work could also include additional engineering service activities to determine the extent to which these findings are generalizable beyond EWB-USA. This research began to investigate this topic; however, as the first large-scale, empirical study of EWB-USA engineers that included a comparison group, more evidence is needed.

In addition, this research focused on one of the two benefactors in engineering service—the students. Service-learning has been supported within engineering as a win-win for both students and the communities in which they are working (IJSLE 2012), and EWB-USA includes both communities and engineers as targeted beneficiaries in their mission statement (EWB-USA 2014); however, many studies like this one have focused on the student benefits while ignoring the impacts to the communities (Riley 2008; Schneider et al. 2008, 2009). Future work on the learning outcomes of engineering service should be mindful to include community impacts be more transparent in the holistic benefits or costs of such experiences.

Implications

Through facing authentic, multidisciplinary, inter-cultural design projects, EWB-USA members apply professional skills in more complex and realistic environments than their peers who work on domestic or fabricated design projects. These challenging experiences provide opportunities to learn additional skill sets that the profession is seeking. Creating professionals with excellent technical skills has been, and will likely continue to be, a strength of the engineering field; creating engineers with excellent technical skills paired with experience-based professional skills is a strength of engineering service activities. Employers and educators who recognize this strength will help prepare engineers to face global sociotechnical challenges.

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CHAPTER 4

The Miner's Canary: Warnings from Socially Engaged Engineers' Search for Meaningful Work

ABSTRACT

Engineers that are actively engaged with both the social and technical dimensions of engineering work—socially engaged engineers—offer diversity in skill sets, values, and characteristics to the engineering workforce which the profession needs to better address complex global challenges. Despite the value of these engineers, the field lacks understanding about their career interests and experiences. This study investigates EWB-USA members as a case of socially engaged engineers to explore students' career expectations and practicing engineers' career experiences. Using mixed-methods and a lens of meaningful work, we attempt to unpack what differences between EWB-USA members and non-members should mean to the engineering field. Findings indicated two main trends among EWB-USA members: females' disillusionment with community development engineering work and strategies for coping with work tensions. We discuss why and how these findings should serve as a miner's canary—a warning to the engineering field about the dangers of socially engaged engineers' misalignment with current engineering careers. Recommendations are outlined to help students, leaders, and employers adjust. Without such adjustments, socially engaged engineers' socio-technical skill sets and passions may leave complex global engineering challenges for others to solve.

INTRODUCTION

Engineering work is social and technical by nature (Stevens et al. 2014); however, for decades, US engineering has been equated with applied science which has left the profession lacking in diversity of both population and skill sets (Lucena 2005; National Academy of

Engineering 2002). Alongside the lack of diverse engineers able to interface between social and technical dimensions, basic domestic and global needs have suffered (e.g., American Society of Civil Engineers 2013; United Nations 2013). This research studies engineers who exhibit socio-technical skill sets (see Chapter 3) and values (see Chapter 2) that align with the needs of the socio-technical profession—we call these socially engaged engineers. In her study of successful women leaving their well-paid careers, Stone wrote, "The exits of highly talented women are the miner's canary—a frontline indication that something is seriously amiss in too many workplaces" (2007 p. 19). In this paper, we apply Stone's metaphor to the engineering workplace. By exploring socially engaged engineers' career expectations and experiences, we show that females' disillusionment and work tension coping strategies are miners' canaries warning for the attention of the engineering profession before these diverse and capable engineers apply themselves elsewhere.

We begin this paper with a review of the literature to illustrate the growth of socially engaged engineering activities and to highlight how socially engaged engineers provide for the needs of broadly skilled, socially responsible, and diverse engineers. Although socially engaged engineers help to fill these needs in the engineering workforce, the field lacks understanding about these engineers' careers and their sense of fit within the engineering. Therefore, we introduce the framework of meaningful work which offers a lens to understand personal and vocational alignment. Using this framework, we present our mixed-methods research approach. Our findings present evidence about the career roles and skills that students expect to need and that practitioners have experienced. We discuss these findings together to offer warnings and recommendations to the field.

Background

Socially Engaged Engineering

The term socially engaged engineering serves as an umbrella term to encompass many similar ideas. Engineering and sustainable community development (Lucena et al. 2010), engineering social justice and peace (Catalano and Baillie 2006; Riley 2008; Vesilind 2005), humanitarian engineering (Moskal et al. 2008; Muñoz and Mitcham 2012), humanitarian development (Amadei and Sandekian 2010), socially responsible engineering (Canney 2013; Douglas et al. 2009), community engagement (Swan et al. 2014), community service and service learning (Bielefeldt et al. 2010; Vogelgesang and Astin 2000) are a few of the names used to describe engineering efforts that intentionally practice engineering as people-oriented. We have chosen the term socially engaged engineering to refer to engineering activities that explicitly incorporate a community, social, or human component, particularly with an ethic of care (Pantazidou and Nair 1999) or empathetic approach (Vesilind 2005). Although engineering work is social and technical by nature, many engineers still view the profession as a technical one (Stevens et al. 2014); intentional *engagement* with the social aspect is a critical component of these activities.

In the last two decades, socially engaged engineering activities have proliferated. For example, many European countries have begun socially engaged engineering organizations under a name similar to Engineers Without Borders (EWB) (Lucena and Schneider 2008). The EWB International website currently lists 55 countries with EWB memberships (Engineers Without Borders International 2014). EWB-USA has grown to over 14,700 members in its twelve years of existence (Engineers Without Borders USA 2014), and similar organizations such as Engineers for a Sustainable World, Bridges to Prosperity, Engineers for Change, etc. have continued to emerge. University-based efforts have also developed more rapidly in the last decade including programs at Colorado School of Mines, Michigan Tech, Purdue, University of Colorado, Penn State, etc. (see list in Lucena and Schneider 2008). Within socially engaged engineering activities, student enthusiasm is high (Lamb 2010), female involvement is above typical engineering settings (Amadei and Sandekian 2010; Bielefeldt 2006), and professional skill sets are enhanced (Budny and Gradoville 2011; Chapter 3). The following section describes how these engineers are filling needs to create a more skilled and diverse engineering profession.

Wanted: Socially Engaged Engineers

Within the last two decades, qualitative studies have begun to expose what takes place in professional engineering work (Stevens et al. 2014), which has revealed a need for more socially component engineers. Fundamental research by science and technology studies scholars (e.g., Bucciarelli 1994; Latour 1987; Law 1987) showed that true engineering work is both social and technical in nature. "Heterogeneous engineering" (Law 1987) is a more accurate description of the work engineers do, which "requires social and technical coordination to bring different parts of a project's work together" (Stevens et al. 2014 p. 122). Despite discoveries of the true heterogeneous nature of engineering work, engineering has been misrepresented in the engineering classroom for decades by equating engineering with science (Downey et al. 2006; Lucena 2005). In reality, many engineering challenges facing the world's poorest already have technical solutions, yet the social component prohibits progress (Kaminsky 2014); therefore, it is imperative that the engineering field continues to broadcast the sociotechnical nature of engineering work and recruit engineers capable of interfacing between social and technical dimensions. Socially engaged engineers have strengths in professional skills that do not compromise their technical skills (Chapter 3); therefore, socially engaged engineers can fill this need in the profession.

In addition to the need for heterogeneous engineers, socially responsible engineers are needed. Increased globalization has resulted in globally-scaled engineering influence, collaboration, and unforeseen consequences that offers engineers wider influence and demands greater responsibility (Douglas et al. 2009). Because of this, engineers are called to work with compassion (Catalano and Baillie 2006; Salazar 2007) and empathy (Vesilind 2005), which are not traits commonly observed among of engineers (Rasoal et al. 2012). Major reports such as the UN's *Millennium Development Goals* (United Nations 2013) and UNESCO's report *Engineering: Issues, Challenges and Opportunities for Development* (UNESCO 2010) have reiterated engineers' roles in relieving humanitarian crises, and the NAE has been actively trying to market a vision of engineering that emphasizes "that engineering and engineers can make a difference in the world" (NAE 2008 p. 11). This vision of engineering has been shown to help recruit young engineers (Klotz et al. 2014), especially females (Schreuders et al. 2009; Seymour and Hewitt 1997). Socially engaged engineering fills a need to develop socially responsible, globally aware engineers.

A third need among engineers is a gender diverse workforce. This need has been well documented as an argument to help improve the quality of engineering solutions (Sonnert 1999). Historically, science and engineering have been defined by a specific group of people that left women out (Eisenhart et al. 1998; Lucena 2005), and, as a result, there are many women who, despite their strong desires to use science and engineering for service (Hewlett et al. 2008), become disillusioned with the field upon entering the workplace unable to reconcile their femininity with their engineering identity (Eisenhart et al. 1998; Faulkner 2009; Hewlett et al. 2008; Kvande 1999; Tonso 2007). Researchers have found that women are drawn to careers that are people-oriented (service careers) rather than thing-oriented (technical careers) (Eccles 2007; Faulkner 2007; Hewlett et al. 2008; Woodcock et al. 2012), which explains why socially engaged engineering activities have been found to attract more women than most engineering settings (Amadei and Sandekian 2010; Bielefeldt 2006). In her study of women's "desire for development," Heron (2007 p. 36) concluded that development work allows women to resolve their multiple identities by participating in "something at once heroic and simultaneously feminine and unfeminine." In addition to socially engaged engineering aligning with women's social and altruistic values, it provides opportunities for females to reconcile their engineering identity with their female identity.

Meaningful Work

Altogether, socially engaged engineers support needed changes in engineering culture: needs for engineers who can interface between the social and technical dimensions of engineering, needs for socially responsible, globally aware engineers, and needs for changing the masculine nature of engineering to better align with feminine values and identities. Filling each of these needs helps to improve the quality and diversity of engineering solutions to challenging societal issues. Although the field values the heterogeneous, socially responsible, and gender diverse population of socially engaged engineers, their rapid growth within the last two decades leaves much to be understood about this population. It is clear that these engineers contribute valuable attributes (Chapter 2) and skills (Chapter 3) to the engineering field, but it is unclear if these engineers are able to find alignment with the engineering profession.

Current perceptions of engineers convey both positive and negative images. For example, stereotypes communicate that engineers are hard-working, committed to objectivity, and desire to help others, but they also communicate that engineers do not personally help others and have narrow technical focuses, poor relationship and communication skills, and passive political participation (Riley 2008). Studies of the history of engineering as a service profession have highlighted that after WWII, US engineering became largely focused on militaristic, political, and corporate agendas (Lucena 2005; Lucena and Schneider 2008; Riley 2008; Seely 2005). If these stereotypes and historical accounts are accurate, then SE engineers may have trouble fitting into this profession.

Therefore, we frame this study using a theory that helps understand personal and vocational alignment, a theory of meaningful work. “Individuals experience work as meaningful when, through the performance of job tasks, work experiences produce perceptions and feelings within the individual that are consistent with the individual’s perceptions of who they are and who they want to be” (Scroggins 2008 p. 62). Desires for meaningful work have been linked to job retention (Scroggins 2008), career engagement (Buse 2011) and job satisfaction (Pratt and Ashforth 2003). Wrzesniewski (2003) classified three types of workers: those that see work as a job, as a career, and as a calling. Pratt and Ashforth (2003) noted that those with a calling find work meaningful by answering the question "Why am I here?" and they have shown that answering this question comes through an integration with personal identity ("Who am I?"). They argued that this integration is achieved through either meaningfulness in a work role ("What am I doing here?") or meaningfulness in workplace membership ("Where do I belong?").

Similar terms such as a sense of belonging, identity, and fit are all terms that have been used to refer to the importance of personal and vocational alignment to help employees engage with and find fulfillment in their work (Ayre et al. 2013; Eccles 1994; Lent et al. 1994). For example, in an interview study of working women engineers, women with a higher sense of belonging in engineering were the ones persisting in the profession (Ayre et al. 2013). Similarly, a key finding of engineering practice across six different firms, noted that "most engineers' identities were also linked to their work meaning something," whether that was for one's company or larger society (Anderson et al. 2010 p. 168). Meaningful work provides a relevant framework for our study because finding meaningful work is important for all engineers' connections and engagement with their work, and the field does not yet understand the career perceptions of socially engaged engineers.

Research Context and Themes

The context for this study was one of the largest and most prominent socially engaged engineering organizations in the US—EWB-USA. "EWB-USA is a nonprofit humanitarian organization established to support community-driven development programs worldwide through partnerships that design and implement sustainable engineering projects, while creating transformative experiences that enrich global perspectives and create responsible leaders" (EWB-

USA 2014). Studying this 14,700+ member organization that spans 286 chapters across the US provided a widespread, diverse population of socially engaged engineers. We compared these engineers with other engineers from around the country who were not involved with the organization, and through these comparisons made probabilistic and theoretical generalizations (Eisenhart 2008) to provide understanding about the careers of socially engaged engineers.

Because we aimed to understand this unstudied population, we used an exploratory mixed-methods approach (Creswell 2009) to compare EWB-USA members and non-members. In the following sections, we begin by describing the methods for both the qualitative and quantitative phases of the study. During the qualitative phase, our focus was to explore students' career goals and expectations and practitioners' intentions to leave or stay in engineering. These results informed the creation of a survey focused on both career roles and career skills (see Table 4-1). We first present the results from the survey of career skills and then present the results for the career roles separated by students first and then practitioners. The results are combined in the discussion to offer warnings and recommendations to the larger field in light of a theory of meaningful work.

Table 4-1: Summary of research topics and themes for the careers of socially engaged engineers

	Students' Expectations	**Practitioners' Experiences**
Career roles	Qual.: Career goals & expectations Quant.: Interest in specific roles	Qual.: Career intentions Quant: Experience in specific roles
	EWB-USA members vs. non-members	
Career skills	Quant.: Expectations of specific career skills	Quant.: Experience with specific career skills

RESEARCH METHOD

We began this mixed-methods study with an exploratory qualitative phase which informed the creation and analysis of a survey. Here we describe the methods for the qualitative phase followed by the methods for the survey creation and data collection.

Qualitative Interviews and Focus Groups

Qualitative methods provide rich data to aid exploration of new perspectives; therefore, we spoke with 165 engineers across the US in 27 interviews and 32 focus groups to understand trends in career intentions. The majority (n=100) were EWB-USA members; 90 were students, 75 were practicing engineers; and 80 were female, 85 were male (Table 4-2). Respondents came from twenty four different US states and studied or worked in eighteen different engineering fields. EWB-USA participants were solicited from EWB-USA conferences and chapters, and where possible, non-EWB-USA members were solicited from the same workplaces or universities as participating EWB-USA members. Because this was an exploratory study aiming for theoretical generalizability rather than probabilistic generalizability —in which cases are selected "based on the likelihood that the case will reveal something new and different" (Eisenhart 2008 p. 60)—snowball sampling was used to reach a variety of respondents including EWB-USA member and non-members, males and females, and students and practitioners for both interviews and focus groups.

Table 4-2: Demographic information for qualitative participants (n=165)

EWB-USA Members 105								Engineers Not in EWB-USA 60							
Females 51				Males 54				Females 29				Males 31			
Practitioners 14		Students 37		Practitioners 30		Students 24		Practitioners 13		Students 16		Practitioners 18		Students 13	
I 5	FG 9	I 4	FG 33	I 3	FG 27	I 3	FG 21	I 3	FG 10	I 3	FG 13	I 3	FG 15	I 3	FG 10

Note: I= interviewees; FG= focus group participants

Interviews were performed by one researcher and focus groups were performed by one or two researchers either in person or through the phone when necessary. Participants were offered light snacks and refreshments or a $10 gift card for their participation. All sessions were audio recorded after consent was given according to IRB regulations. Interviews lasted approximately 40 minutes and focus groups lasted about one hour. Focus groups were either entirely male, entirely female, or mixed-gender; however, students and practitioners as well as EWB-USA members and non-members were not mixed together. Questions followed a semi-structured approach (Spradley 1979), and they differed slightly for students and practitioners as well as for EWB-USA members and non-members. General topics included career goals and expectations. Example prompts included, "Describe what you would like to do outside of school" (students); "Do you intend to stay in engineering?"; "Describe what, if anything, [your engineering activity, such as EWB-USA] has meant to your career" (practitioners).

All audio recordings, totaling over 36 hours, were transcribed, checked for accuracy, and uploaded into qualitative coding software, QSR NVivo 10. Coding was primarily deductive, using respondents' direct words to determine emergent themes for students' career goals and for practitioners' intentions to stay or leave engineering. We used a coding dictionary to track themes' definitions as recommended by Miles and Huberman (1994). Following preliminary coding, both case-oriented and variable-oriented approaches were adopted for more thorough analysis (Miles and Huberman 1994). Our variable-oriented methods included grouping and summarizing techniques among emergent codes to look for cross-case patterns, and our case-oriented methods included interviewees as the unit of analysis to search for literal and theoretical replication of findings (Yin 1994). Each interview transcript was reread and summarized looking for trends within and between both EWB-USA members and non-members. Focus group data was used to triangulate findings (Mathison 1988).

Survey Creation and Collection

To inform the official, large-scale survey, we first piloted the survey at a large research university in the Western US. Of the 5,000+ engineering students solicited for this survey, 566 completed surveys were received and analyzed. The findings from this pilot research have been published elsewhere (Litchfield et al. 2014). This step helped to test survey items and analysis prior to their official use.

The official survey population came from organizational membership databases of four major US professional engineering organizations: American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), Society of Women Engineers (SWE), and EWB-USA. Because obtaining a random sample of all American engineers would not be possible, these organizations were selected purposefully in order to achieve a sample that was representative of the two comparison groups of interest for this study (EWB-USA members and non-members). Soliciting ASCE and ASME memberships provided a large population of non-EWB-USA engineers that represented engineering disciplines similar to many EWB-USA projects. Because EWB-USA has approximately 40% female membership (Amadei and Sandekian 2010), which contrasts typical engineering settings with 20% or less females (Fouad and Singh 2011), we solicited SWE members to ensure that the non-EWB-USA group had a gender ratio closer to that of EWB-USA because literature suggested that gender was an important component to understanding socially engaged engineers.

Because all four organizations had differing membership privacy policies, each organization was solicited individually. In general, an anonymous link to the online survey hosted in Qualtrics survey software was sent via email by the host organization. Two organizations sent the link to their entire active, US-based membership while two organizations sent the link to a sample of their membership to minimize over-solicitation of their members. In total, the questionnaire was sent to 118,036 organizational members and remained open for one month during 2014.

Survey items relevant to this paper included items for demographic information, career skills, and career roles. Demographic items included gender, year of birth, organizational membership, and organizational membership status (student or practitioner). Items for career skills listed fifteen career skills (see Table 4-4) that were identified in previous research as important skills for an engineer to know (Litchfield and Javernick-Will 2014). Participants were asked to rate "How much do you need/expect to incorporate the following skills in your own engineering career?" from 1 (not at all important) to 5 (crucial).

Items for career roles were created with the goal to move beyond the binary view of "engineering roles" and "non-engineering roles." Because careers in socially engaged engineering may or may not be considered engineering roles by some, we provided participants with more specific roles to make comparisons between EWB-USA members and non-members. The research team brainstormed a list of roles in line with results from students' qualitative responses, and, to finalize the list for the survey, three phone interviews were held with professional engineers: a female CEO of a large consulting firm, a male with over 40 years of professional experience and future president of a large professional engineering organization, and a male vice president of a global consulting organization. Interviewees were informed of the purpose of the research, sent the list of roles, and asked for suggested changes based on their work and leadership experience. After these interviews, twelve roles were finalized for the survey (Table 4-5). Students were asked, "How likely is it that you will be doing each of the following in the next five years?" with a scale of 1-5 (definitely not to definitely yes). Practitioners were asked, "Which roles have you been in since graduating with your engineering degree?" with the option to select as many of the listed roles as applicable. Practitioners were also asked, "Of the options listed below (same as previous question), is there a role in which you have interest for switching into?" with the additional option, "I have no interest in switching roles." Only one option could be selected for this question.

Analyses separated students and practitioners as well as EWB-USA members and non-members. First, tests of comparison were run to compare EWB-USA members and non-members' demographics—chi-square tests of proportions for percentages of females and t-tests on the mean age (year of birth minus the year 2014). To make comparisons between EWB-USA members and non-members that would control for significant differences in potentially confounding variables of gender and age, multiple logistic regression models were used. In each model, the outcome variable was a survey item response. For Likert-style items (career skills and career roles for students) we used ordinal logistic regression models, and we used logistic regression models on the items with a dichotomous response to career experience. In each model, a dichotomous variable for EWB-USA membership—either official or unofficial involvement with the organization as indicated by survey respondents—was the main predictor variable, where 1 indicated membership. A dichotomous variable for gender, where 1 indicated female, and a continuous variable for age were control variables.

RESULTS

In the following sections, we present the qualitative and quantitative results together. We first present the survey demographics with results from the tests of comparison followed by the regression results from the items for career skills. Because the interest in career skills emerged after the qualitative phase of the study, there was no qualitative evidence for the skills portion of the study. We then present the results from the students' career role expectations and practitioners' career role experiences. Results for each of these two sections are presented as qualitative coding frequencies, followed by regression results, and then further qualitative evidence. For this paper, pseudonyms were assigned to qualitative participants. To help differentiate, EWB-USA members were given names beginning with the letter "E" and non-members were given names beginning with the letter "N."

Survey Results: Demographics

In total, 118,036 organization members received the questionnaire (31% students, 28% females, and 7% EWB-USA members), and 2,896 completed it (29% students, 25% females, and 25% EWB-USA members)—a 2.5% response rate. Due to the large number of solicitations, this low rate was not surprising, and because there was no reason to believe that the response population was significantly different from those that did not respond, we were not concerned with self-selection bias. The survey was positioned as a university-based National Science Foundation funded Research in Engineering Education study unaffiliated with any specific engineering organization.

Respondents with missing data for student or practitioner status, gender or age were removed from the data set along with those who did not study engineering and who were not US citizens. Because we were interested in EWB-USA members specifically, we limited the questionnaire population to US citizens. We also removed respondents who indicated that they were involved with an engineering service organization similar to, but not including EWB-USA. We initially intended to use this group for a separate comparison; however, because respondents listed such a wide variety of related organizations, many of which were not clearly service or engineering related, we eliminated this group in order to remove potentially confounding results. Demographic breakdowns of the remaining 642 student and 1586 professional respondents, separated by EWB-USA members and non-members, showed that EWB-USA members had significantly more females and a younger population than non-members (Table 4-3).

Table 4-3: Demographic information for survey respondent population by students and practitioners

	Students (n=642)				Practitioners (n=1586)			
	EWB-USA (n=290)	Non-EWB (n=352)	Test Stat	p-value	EWB-USA (n=324)	Non-EWB (n=1262)	Test Stat	p-value
Percent Female	52.1%	37.8%	X^2=13.2	<0.001	24.7%	16.1%	X^2=13.0	<0.001
Mean Age	23.3	25.5	t=4.80	<0.001	47.1	49.5	t=2.39	0.017

As with the students, EWB-USA practitioner members had significantly more females and a younger mean age; however, both EWB-USA practitioners and non-member practitioners had percentages of females that were less than half the percentages of females in the student groups. These results reflect the decrease in the percentage of females from engineering universities (20%) to workplaces (11%) (Fouad and Singh 2011).

Survey Results: Career Skills

Results from the ordinal logistic regression models for career skills share the odds ratios with the standard deviations in parentheses (Table 4-4). The skills are listed in order of mean student scores for all students. EWB-USA members and non-members had very few differences in skills' rank order, the most noticeable of which was "awareness of engineering impact" ranked as number nine for EWB-USA members and number eleven for non-members. The top three skills for both EWB-USA members and non-members were problem solving, an ability to work in teams, and communication skills for both students and practitioners. These results aligned with the top three traits Anderson et al. (2010) found as identifiers of engineering practice. Levels of significance for EWB-USA membership, gender, and age variables are indicated with asterisks; however, we focus the results on significant differences between EWB-USA members and non-members.

Several significant differences were found among students. Lifelong learning was the only career skill for which EWB-USA membership was significantly related where membership indicated *less* expectation of the skill controlling for age and gender. This skill was not significantly different among EWB-USA and non-EWB practitioners. Students showed five skills for which EWB-USA membership was significantly related where membership indicated a *higher* expectation of needing the skill on the job: awareness of engineering impact, societal awareness, global perspective, non-technical skills, and humanitarian emphasis. These five skills were among the six lowest ranked skills of the list of fifteen. For EWB-USA members, the odds of expecting to need a humanitarian emphasis and a global perspective once working were over twice the odds of non-members, controlling for gender and age. EWB-USA practitioners showed similar results for the same five skills.

In addition, practitioners indicated that EWB-USA membership was significantly related to the skill of teamwork controlling for gender and age where membership indicated a *higher* need for teamwork skills. Practitioners also showed that technical skills were related to EWB-USA membership where membership indicated *less* need for technical skill in an engineering career than non-membership. Overall, practitioners ranked technical skills two spots higher than students; non-EWB members ranked technical skills as their third highest skills while EWB-USA practitioners ranked it fifth. With the exception of lifelong learning, teamwork, and technical skills, students and practitioners showed similar results in comparisons of career skills between EWB-USA members and non-members. EWB-USA students showed expectations for needing certain skills in their careers more than non-members which aligned with the skills that EWB-USA practitioners found to be needed in their careers more than non-members. These differences primarily surfaced among the lower ranked skills for engineering work; however, those skills are in line with those pointed out by the NAE as important professional skills for engineers of the future (NAE 2004). These findings point to the need for more research to understand how and why these skills are needed more among EWB-USA members.

Students' Career Expectations

Of the 90 students that participated in the qualitative phase, 74 offered descriptions of their future career goals. Themes that emerged from the data included jobs in *community development, engineering, international work, management, non-engineering, public policy or government,* and *teaching*; additional themes emerged for intentions to attend *graduate school*, to *help people*, to do *something like EWB* as a job, to *use engineering* somehow, and to *volunteer or find a meaningful outlet* (such as EWB-USA). A final theme of respondents being *unsure* about their career goals also emerged. Among these thirteen themes, intentions to pursue an engineering job were most common among Non-EWB-USA females (90%, n=9), Non-EWB males (60%, n=6), and EWB males (52%, n=11). About 36% (n=12) of EWB-USA females responded with explicit intentions to work in engineering; however, the most common theme for EWB-USA females (45%) was *community development* (Figure 4-1). In contrast, only 14% of the EWB-USA males expressed intentions to work in community development, and no students not involved with EWB-USA expressed community development intentions. Because the intentions of the coding were exploratory, no statistical tests were run to compare themes. Instead, the results informed areas to investigate further with survey items and in the interview cases.

Results from the regression models for each career role are shown in a similar format to results from the career skills (Table 4-5). As mentioned previously, due to the differences in survey questions between students and practitioners, ordinal logistic regression models were run for the students and logistic regression models were run for the professionals. Among students, teaching in an engineering-related subject was the only role with a significant relationship to EWB-USA members in which members were *less* likely to expect to work in that role controlling for gender and age. Six other roles showed significant relationships with EWB-USA membership where membership was associated with *higher* expectation to work in the role: engineering project management, non-profit organization doing community development, a role other than engineering design, research, or management, a role in public policy, government or law, a professional degree (e.g. business, medicine, etc.), and not working full time by choice. (The specific wording of the professional degree item said, "Using the engineering degree as a stepping stone to a different professional degree (e.g. medicine, law, business).") Many of these roles extend a broader application of engineering. The most notable difference was for the role in non-profit community development where, for students in EWB-USA, the odds of being in any one Likert category as opposed to a category below it were over three times the odds for non-EWB students.

Table 4-4: Odds ratios from ordinal logistic regression models for career skills

	Student Expected Skills (n=642)				Practitioner Needed Skills (n=1586)			
Career Skill	**Rank**	**EWB-USA**	**Age**	**Gender**	**Rank**	**EWB-USA**	**Age**	**Gender**
Problem solving	1	0.78(0.14)	1.01(0.02)	1.14(0.20)	1	1.03(0.13)	0.99(0.003)*	1.24(0.18)
Ability to work in teams	2	1.31(0.22)	1.00(0.01)	1.20(0.20)	3	1.28(0.16)*	0.98(0.003)***	1.70(0.24)***
Communication skills	3	1.10(0.18)	1.04(0.02)*	1.37(0.22)	2	1.21(0.15)	0.99(0.003)**	1.61(0.22)**
Lifelong learning	4	0.70(0.11)*	1.04(0.01)*	1.07(0.17)	6	1.26(0.15)	1.00(0.003)	1.37(0.17)*
Interpersonal skills	5	1.11(0.17)	1.02(0.01)	1.28(0.20)	5	1.15(0.13)	0.99(0.003)*	1.54(0.20)**
Technical skills	6	0.83(0.13)	1.02(0.01)	1.15(0.18)	4	0.73(0.09)*	1.00(0.003)	0.85(0.11)
Project management skills	7	1.19(0.18)	0.99(0.01)	1.18(0.18)	7	1.12(0.13)	0.99(0.003)	1.42(0.18)**
Hands-on application	8	1.03(0.16)	0.99(0.01)	1.16(0.17)	9	0.89(0.10)	1.00(0.003)	0.93(0.12)
Creativity	9	0.88(0.13)	1.00(0.01)	0.93(0.14)	8	1.08(0.13)	1.01(0.003)***	0.92(0.12)
Awareness of engineering impact	10	1.55(0.23)**	1.01(0.01)	1.45(0.22)*	10	1.78(0.21)***	1.00(0.003)	1.01(0.13)
Networking	11	1.06(0.16)	0.99(0.01)	1.04(0.15)	11	1.11(0.13)	0.99(0.003)***	1.28(0.16)*
Societal awareness	12	1.96(0.29)***	1.00(0.01)	1.36(0.20)*	13	2.45(0.28)***	1.00(0.003)	1.60(0.20)***
Global perspective	13	2.40(0.36)***	1.01(0.01)	1.27(0.18)	14	2.58(0.30)***	1.00(0.003)	1.39(0.17)**
Non-technical subjects	14	1.55(0.23)**	1.02(0.01)	1.60(0.24)**	12	1.73(0.20)***	1.01(0.003)*	1.63(0.21)***
Humanitarian emphasis	15	2.56(0.39)***	1.00(0.01)	1.34(0.20)*	15	2.97(0.34)***	1.01(0.003)***	1.31(0.16)*

*p<0.05, **p<0.01, ***p<0.001

Table 4-5: Odds ratios from regression models for career roles

	Student Interests (ordinal logistic regression; n=642)				Practitioner Experiences (logistic regression; n=1586)			
Career Role	**Rank**	**EWB-USA**	**Age**	**Gender**	**Rank**	**EWB-USA**	**Age**	**Gender**
Engineering design or development	1	0.90(0.14)	0.97(0.01)*	0.72(0.11)*	1	0.69(0.10)**	1.00(0.004)	0.68(0.11)*
Graduate school within engineering	2	0.94(0.14)	1.01(0.01)	0.95(0.14)	3	1.18(0.16)	1.01(0.003)*	1.36(0.20)*
Engineering researcher	3	0.83(0.12)	1.02(0.01)	0.99(0.14)	4	1.00(0.14)	1.03(0.004)***	1.18(0.19)
Engineering project management	4	1.40(0.21)*	0.98(0.01)	0.92(0.14)	2	1.43(0.19)**	1.03(0.004)***	0.75(0.11)*
Non-profit org. community development	5	3.32(0.52)***	0.99(0.01)	1.56(0.23)**	9	6.21(0.13)***	1.02(0.006)***	0.57(0.16)*
Engineering upper level management	6	1.27(0.19)	0.99(0.01)	0.82(0.12)	5	1.37(0.21)*	1.05(0.005)***	0.67(0.13)*
Other than eng. design, research, or management	7	1.38(0.20)*	1.01(0.01)	1.32(0.19)	6	1.26(0.18)	1.02(0.004)***	1.26(0.21)
Public policy, government, or law	8	1.77(0.26)***	1.02(0.01)	0.83(0.12)	8	1.83(0.28)***	1.03(0.005)***	1.16(0.22)
Teacher in engineering-related subject	9	0.71(0.11)*	1.04(0.01)**	1.03(0.15)	7	1.59(0.25)**	1.04(0.005)***	0.89(0.18)
Professional degree	10	1.75(0.26)***	0.99(0.01)	0.96(0.14)	12	1.75(0.60)	1.02(0.01)	1.21(0.51)
Not working full time by choice	11	1.42(0.22)*	0.99(0.01)	1.47(0.22)*	10	1.81(0.39)**	1.06(0.007)***	2.16(0.57)**
Military engineer	12	0.78(0.12)	0.95(0.01)**	0.59(0.09)**	11	1.45(0.34)	1.05(0.007)***	0.13(0.09)**

*p<0.05, **p<0.01, ***p<0.001

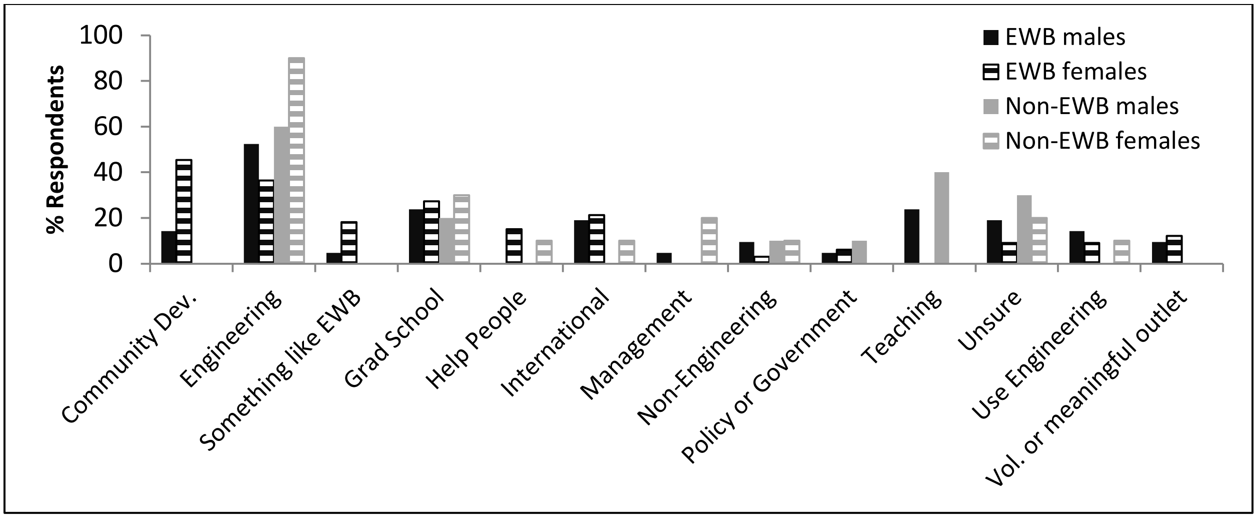

Figure 4-1: Coding themes from students' career goals by gender and EWB-USA membership

Based on the qualitative coding and regression results, community development was a key theme to explore further through the interview cases. All four female student interviewees involved with EWB-USA expressed interests in working in community or international development jobs. For example, although Erin expressed that she wanted to "*check out the corporate world before I build a non-profit route*." She continued, "*I'd like to say that I will get a good mix of the corporate world before I jump into my work*," which implied that the "*non-profit route*" was her longer term goal. Only three EWB-USA male students of the 24 with responses expressed intentions for community or international development career goals, two citing interests in Peace Corps and one debating working or volunteering in development. Instead, some males referred to EWB-USA as an enjoyable activity that they may or may not continue once working. For example, Eric noted that EWB-USA was "*more of a hobby*" in school, "*one that offered the opportunity to travel to a cool place on somebody else's nickel, or on somebody else's couple thousand dollars*." This sentiment was not found among female interviewees, many of whom preferred EWB work as a career choice such as Erin who said, "*My mind is definitely set on continuing with what EWB does, but as a life choice not as a hobby*."

Although non-EWB females did not express interests in community development, a social component to future work was common among females. Except for Natasha, all female student interviewees discussed their career goals in ways that included people. Nora claimed that she "*chose structural [engineering] because I wanted to always build the buildings that affect people*," and Nicole, having grown up visiting construction sites with her dad, wanted that "*family-like atmosphere*" she perceived in construction management. Similarly, all EWB-USA female interviewees expressed intentions to combine engineering with their interests either working with people or helping people. For example, Elena, a graduate student native to Bolivia, expressed, "*to be able to actually help people of the country or countries from where I come from is one of my main drives*." The females' career goals aligned with literature that notes the importance of social and altruistic careers for women (Eccles 2007; Faulkner 2007; Hewlett et al. 2008; Schreuders et al. 2009; Seymour and Hewitt 1997; Woodcock et al. 2012). Overall, findings about students' career goals illustrated that many EWB-USA females had interests in development careers or jobs with an altruistic component. Women not involved with EWB-USA were less likely to express altruistic goals, but many mentioned interests in the social side of their future work.

Practitioners' Career Intentions

Of the 75 practicing engineers who participated in the qualitative phase, 41 offered explanations for their intentions to stay or leave engineering. Following initial thematic coding, themes appeared to follow the patterns of work as a job, career, or calling from meaningful work literature (Wrzesniewski 2003) and were grouped accordingly. Emergent themes grouped within "non-calling"—viewing work as a job or career—were: being able to *make money*, *climb a corporate ladder*, or work as a *means to achieve other goals*. For example, Nolan claimed that engineering was "*just a method to provide me the availability to reach some of my other goals which are far more personal.*" Themes grouped within "calling" incorporated Pratt and Ashforth's (2003) two types of meaningful work: (1) a sense of belonging included themes of enjoying one's particular *work* *environment*, enjoying *working with people*; and (2) enjoying work roles with themes of *learning skills*, and wanting to *help (in general), help the earth*, and *help people*. For example, Noel, with 28 years of experience in transportation, said that she found it rewarding to "*tackle a task successfully*," which demonstrated meaningful work achieved through work roles. In a female focus group, Nancy shared that she stayed at her current job due to the people she worked with, "*If I didn't feel valued here I probably would have moved back to [my home state] by now.*" This demonstrated meaningful work though a sense of belonging. Respondents within both the calling and non-calling themes intended to stay in their engineering career.

Some respondents were hesitant in their response about staying in their career. These responses grouped into three new themes, all of which expressed some type of strategy for coping with tension about work. The first of these themes was when people found that *EWB-USA* helped them stay at work, the second was when people expressed their efforts to *adjust their job* or their daily work to make it more satisfactory, and the third was when people wanted to *leave their work to work directly with people* more. Results divided by EWB males (n=5), EWB females (n=6), Non-EWB males (n=17), and Non-EWB females (n=12) are presented as relative frequencies (Figure 4-2). As with the student results, these themes were used to understand trends in the data rather than to test for statistically significant differences.

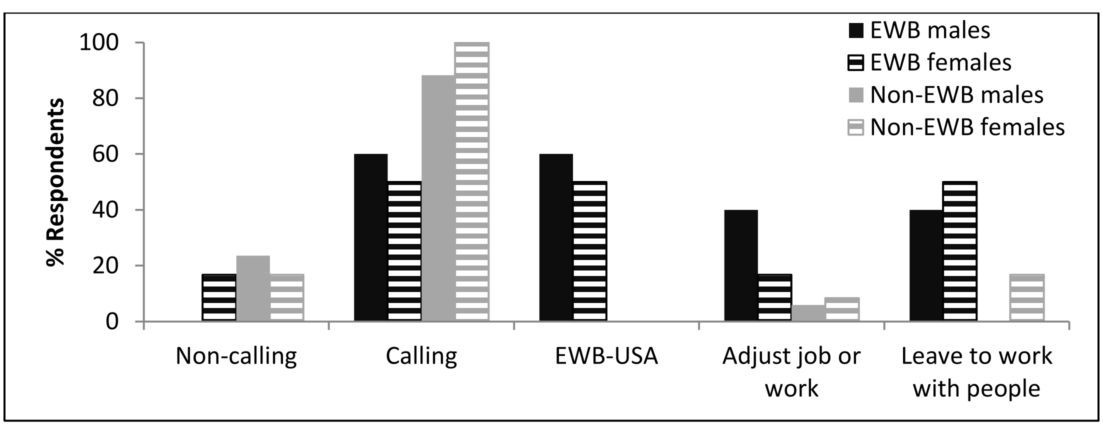

Figure 4-2: Coding themes from practitioners' career intentions by gender and EWB-USA membership

Most practitioners, including 100% of the female non-EWB members who offered an explanation, discussed intentions to stay in engineering due to the meaningfulness of work—work as a "calling." This was likely heavily influenced due to the fact that our sample was entirely working engineers. Interviewees often spoke of engineering work as rewarding or fulfilling. For example, Noah, a civil engineer nearing retirement said that looking back on his work helped him, "*feel like I was doing something to help out the world*." Emma said her engineering career was "*super fulfilling in terms of life goals*." Among both EWB-USA members and non-members, males and females, the trend of satisfaction at work was consistent, although fewer EWB-USA members responded in the calling theme than non-members (n=26, n=7). More EWB-USA members than non-members discussed strategies to cope with work tensions (n=9; n=4), which are described further in the discussion section.

In the survey, practitioner EWB-USA members indicated significant differences from non-members in different roles than those found among the students. EWB-USA practitioners were significantly *less* likely than non-members to have worked in engineering design or development controlling for age and gender; members were also *more* likely to have had experience in upper level engineering management and as a teacher in an engineering-related subject than non-members. Unlike student members, practitioner members and non-members did not show significant differences in their experiences working in something other than engineering design, research or management and in obtaining a professional degree. Similar to the students, EWB-USA practitioners showed significantly *more* experience than non-members in roles of community development, public policy, government or law, and not working full time by choice. Although space in this paper does not allow for in-depth discussion of the gender and age variables, one notable gender difference was in the community development role. Controlling for age and EWB-USA membership, the community development role was significantly related to gender for both students and practitioners; however, female students were *more* likely to expect to work in that role than males, while female practitioners were *less* likely to have had experience in the role than males. This difference flags misalignment between students' expectations and practitioners' reality.

For the survey item asking practitioners about their interest in switching career roles, the response for "I have no interest in switching roles" was analyzed. Half of the male non-EWB-USA members, 41% of the male EWB-USA members, 42% of the female non-EWB-USA members, and only 30% of the female EWB-USA members were not interested in changing career roles. Logistic regression indicated that EWB-USA membership was significantly related to this response (OR=0.685, SD=0.09, p=0.004) where EWB-USA members were much more likely to be interested in changing career roles than non-members. Female EWB-USA members were most interested in switching roles among all four groups.

Discussion

The results presented above indicated that EWB-USA students expected to need more broad skills and were interested in career roles that extended the application of engineering, particularly in areas of international or community development, more than non-members. EWB-USA practitioners indicated that they used more broad skills in their careers, had more experience in career roles that extended the application of engineering, and were less content in their current job role than non-members. The following discussion combines the results from the students' expectations and the practitioners' experiences to uncover two major differences between how EWB-USA members and non-members viewed their careers: females' disillusionment and finding meaningful work.

Females' Disillusionment

The first major difference between EWB-USA members and non-members in their career expectations and experiences was a trend of EWB-USA female members' disillusionment with engineering careers. Results from the regression analyses of practitioners' career skills showed ten career skills for which females indicated more need in their jobs than males. Of these ten skills, seven involved a social element (e.g. communication skills). Female students did not show as many significant differences from males as the practitioners did, which suggested their misalignment with workplace reality.

Results from career roles indicated further misalignment between expectations and reality, particularly about careers in community or international development. Female EWB-member interviewees expressed enthusiasm about development work, and females in the survey showed higher interest in community development roles than men; however, the survey showed that practicing females had less experience in community development than the men, even when controlling for age and EWB membership. In addition, over two thirds of female EWB-USA members desired to change career roles, which signaled discontentment at work. These findings echo findings of female engineers' disillusionment when they transition into the workplace and expectations do not align with reality (e.g., Eisenhart et al. 1998; Hewlett et al. 2008; Kvande 1999). Female socially engaged engineers may face a similar type of disillusionment about the realities of finding community development work. This disillusionment is not a challenge for all females, nor is it a challenge for females only; however, there is a trend in favor of females in particular, which aligns with the masculine culture of engineering.

The implications of such disillusionment is potentially harmful, particularly if socially engaged engineering continues to grow as a recruiting tool to attract diverse students to engineering (Riley 2008; Vandersteen et al. 2009). These findings should serve as a warning to the engineering field. Without awareness of the potential misalignment between students' desires and practitioners' realities, EWB-USA students with ambitious goals and strong enthusiasm may get lost in their transitions—students like Elsa, who said,

> *I really wanted to do engineering, but not like smartphone engineering. I wanted to do a different kind of engineering, like world politics engineering. I don't want to work in a process plant; that is not why I'm studying engineering. It doesn't have to be limited to that, and I get comfort from being in EWB because I have kind of stopped doubting that engineering was the right thing.*

EWB-USA helped encourage Elsa that she can do engineering in a new way, but does workplace culture suggest otherwise? Will students like Elsa get lost navigating their desire for "*world politics engineering*"? EWB-USA females' potential disillusionment with socially engaged engineering should serve as a warning to their potential disillusionment with engineering altogether, as it may be viewed as a field that misaligns with their interests and values.

Finding Meaningful Work

The other major way in which EWB-USA members and non-members differed in this study was in their intentions for staying in engineering. As evidence from the qualitative coding scheme illustrated (Figure 4-2), engineering was less of a calling to EWB-USA members than non-members, and EWB-USA members expressed more tensions in their decision to stay in their career. This did not necessarily indicate that EWB-USA members were less likely to stay in engineering, but rather that EWB-USA members needed to find other reasons to stay in engineering, which surfaced as strategies to cope with work tensions. Here we describe the strategies, which we grouped into three themes, and what they can reveal about helping socially engaged engineers find meaningful work.

The first tension coping strategy was balancing work and EWB-USA activities. For example, Elise shared, "*I think about leaving every day to do something more like EWB*," but she continued, "*having found Engineers Without Borders and knowing that I can do engineering and still be doing something I love has actually kept me in engineering whereas otherwise I probably would have literally departed from engineering and gone back to school and done something totally different*." Over 50% of the EWB-USA members who shared career intentions (n=11 total) responded in this theme, and Elise epitomized this group who expressed that EWB-USA helps them stay with their engineering work. Both women and men used EWB-USA participation as a support for workplace challenges, which showed that it was not only women who found such activities meaningful additions to engineering work. Non-EWB women also discussed fulfilling engineering hobbies, such as Naomi who participated in her state's affordable housing organization. She shared that this experience gave her a "*sense of fulfillment*" that she was "*helping society*" by being "*able to take by knowledge of construction and build homes for people.*" However, women such as Naomi did not share a sense that these activities helped them stay in engineering or find meaning in engineering like Elise. From participants such as Naomi, it appeared that this strategy may not be unique to EWB-USA members, but that it could extend to engineers with a pro-social interest. This strategy highlighted the importance of support for socially engaged engineering activities in the workplace to find meaningful work.

Another tension coping strategy was *adjusting one's job or work role*. Easton, a participant in a mixed-gender focus group, noted that because EWB-USA students had been "*flying all over the world*," they had trouble staying at certain jobs ("*in a cubicle with no windows*"), just like he did. At his first job, Easton had wanted to work on renewable energy projects rather than petroleum projects, and he pushed back until he was able to change roles at his company. He claimed that "*…the reason I've stayed an engineer is because I continue to apply my skills in a necessary transformation where we redefine what is acceptable and what is possible within the engineering profession*." In meaningful work literature, this concept is referred to as "job-crafting," when an individual creates physical or cognitive changes in their work, which is one tool to increase meaning found in and at work (Wrzesniewski 2003). Erica demonstrated "job-crafting" when she shared that she recently moved to a management position because, "*I'm also pretty good at making a voice for myself; making myself known to my bosses and making them aware of what I want to do.*" In these examples, EWB-USA members adopted strategies of job-crafting to make work personally meaningful. The two non-EWB participants who expressed making adjustments to their work (one male and one female) shared stories of staying in engineering due to decisions to change fields of study within engineering whether at school or by going back to school. They did not express adjustments made in the workplace like the three EWB-USA members. Although Easton referred to EWB-USA members when he spoke of those coming from college "*flying all over the world,*" many other socially engaged engineers with similar experiences may find the need to job-craft as they attempt to find meaningful work. This strategy highlighted the importance of allowing for job-crafting to help these engineers align work with their personal values.

The third tension coping strategy emerged from a desire to leave their current job to work with people more. For example, in her female focus group, Elizabeth stated that she wanted to go back to school in environmental engineering and "*then continuing on development work in other areas because I think that that is probably the right balance that I am looking for where there is that people component and I can stay technical*." She added, "*I make a lot of money, but is it fulfilling? No. So, I need to reevaluate*," and she expressed that she had "*a plan to transition into something that I find more rewarding*." Both EWB-USA males and females shared desires to work with people more as well as two non-EWB females. In reviewing the cases of these two women, each expressed interests that aligned with socially engaged engineering. For example, in a mixed-gender focus group Nicky, shared, "*the hard part with engineering is that I don't get to work with the public enough*." Nicky expressed that she often volunteered and mentored people and said, "*I will sometimes still think about going back to school and do counseling or something like that*." During the focus group, Nicky noted that EWB would be a good fit for her and showed that her interests aligned with socially engaged engineers. For all respondents in this theme, an interest in working with people prompted these engineers to consider leaving their current work roles for something more in line with this social value. This strategy flags that despite the heterogeneous nature of engineering work (Stevens et al. 2014), many engineers may be lacking that social connection that can provide meaning to their work and keep them in their careers.

Warnings from the Miner's Canary

Examining the career intentions of EWB-USA engineers as they compare to engineers uninvolved with the organization highlighted two warnings about socially engaged engineers: females' disillusionment and the tensions in finding meaningful work. Our focus group participant Easton expressed his similar discovery when he said, "*I [have] talked to a lot of engineers at EWB events, young engineers who without any reservation say to me, 'This is a job I'm going to resign from and not retire from. It's a matter of time before I find something worth resigning.'*" For him, this had already been true. Why? Because, as he expressed when speaking about EWB-USA members, "*We're going to be pretty hard to impress with business as usual status quo engineering.*" EWB-USA members, and socially engaged engineers more broadly, can fill needs for engineers who can interface between social and technical components, are socially responsible and globally aware, and offer more balanced gender diversity; however, "*business as usual status quo engineering*" may deter these engineers from applying themselves to current engineering challenges. This is the miner's canary—the warning that without change, this growing population of broadly skilled, passionate, and diverse engineers may not find meaning in their engineering work and may end up leaving behind the complex, global engineering problems which they are especially skilled to address.

CONCLUSION

In this paper, we have reviewed how socially engaged engineers fill needs in the profession that can help solve the complex global engineering challenges facing society. Although the field has begun to embrace the benefits of socially engaged engineering, particularly for students, little was known about the career intentions of such engineers. This research showed that EWB-USA students expect to need skills and expect to work in roles similar to non-members, and that they expect to need a set of broader skills and work in some roles that expand the application of engineering. Similar results were found among practicing engineers; however, practitioner and student differences highlighted that EWB-USA females may face disillusionment about the reality of working in community development roles. Although many students were interested in these roles, few practitioners had worked in them. In addition, EWB-USA practitioners revealed coping strategies to help them find meaningful work in engineering. These findings serve as warnings to the engineering field about needed changes to be able to better address complex global engineering challenges.

Recommendations

Based on these findings we offer four recommendations for the engineering field to help socially engaged engineers find meaningful work:

1. EWB-USA and those who provide socially engaged engineering opportunities (such as engineering faculty) should teach students about the social nature of engineering, raise awareness about potential disillusionment, particularly for females, with certain engineering careers, and help them explore avenues to apply their passions and skills that are personally meaningful.
2. Those who participate in socially engaged engineering opportunities should be mindful of their career expectations and goals and communicate them clearly with future and current employers to work together to help them contribute and find meaningful work.
3. Employers should support or continue to support (as many do) EWB-USA and other socially engaged engineering activities in which employees can partake. EWB-USA was a coping strategy for several engineers to find meaning at work, and support for such participation can help employees choose to stay in their job.
4. Employers should also be aware of socially engaged engineers' unique skills and values that necessitate different work roles than other employees. Allowing for job-crafting and interaction with social components of their work may help these engineers better engage with their work.

Limitations and Future Work

Limitations of this work offer opportunities for further work. Due to the exploratory nature of this study, the qualitative data was limited to topics of career goals and intentions developed early in the study without applying of the lens of meaningful work to interview questions. Further application could validate these findings by investigating such questions in the qualitative data collection. Similarly, this study was limited by the length of the survey to focus on items of career skills and roles without allowing for more items to assess identity and meaningful work. Measuring socially engineers' sense of meaningful work and its origins would be valuable contributions to this initial research. In addition, this study focused on EWB-USA engineers as a case of socially engaged engineers. Future work can expand this population to other socially engaged engineering activities, including curriculum based activities, to validate the generalizability of these findings. Socially engaged engineering is growing, and the opportunities for engineers to find meaningful work with the intentional integration of a social component is clearly an important reason for this growth; however, this research highlighted socially engaged engineers' misalignment with current engineering careers. With needs for sociotechnical, compassionate, and gender diverse engineers, the engineering field cannot afford to ignore these warnings much longer.

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CHAPTER 5

CONCLUSIONS

The goal of this research was to characterize and understand the growing population of socially engaged engineers through a study of EWB-USA members. This was an important population to study because they appeared to relieve many of the challenges within US engineering culture, namely, lack of gender diversity, lack of sociotechnical skills, and lack of global social responsibility; however, there was a dearth of research that described and analyzed these engineers. In response to the main research question—*how are engineers involved and uninvolved with EWB-USA different and similar*?— I found that EWB-USA members and non-members were similar in their engineering personality traits, their intrinsic motivations to study engineering, their perceived technical skills, and their interest and experience in working several engineering jobs; however, I also found that EWB-USA members exhibited broader personality traits, more altruistic reasons for studying engineering, stronger perceived professional skills, and some broader career interests and experiences.

Although several of the findings encourage support for socially engaged engineering activities such as EWB-USA, the findings also present warnings to the field. Chapter 2 warns that socially engaged engineers' personal values differ from the other engineers' values, which may flag challenges with misalignment between socially engaged engineers and the current mainstream engineering culture. In addition, Chapter 4 warns that socially engaged female engineers in particular may become disillusioned with their engineering careers, and that socially engaged engineers may need strategies to find meaning in their engineering work. Overall the findings and warnings from this research present the first large-scale empirical data with a comparison group to characterize engineers involved in socially engaged engineering. In this concluding chapter I present theoretical and practical contributions, limitations, ideas for future research, and closing thoughts on the direction of the field and my hopes for this dissertation. A summary of selected contributions is shown in Table 5-1.

Table 5-1: Gaps and selected contributions from each chapter

	Chapter 2	Chapter 3	Chapter 4
Central problem: Need to characterize and understand socially engaged engineers			
Theme	Personal values: interests, motivations, & personality traits	Technical and professional learning experiences and skills	Students' career expectations & practicing engineers' career experiences
Literature Gaps	• No studies of motivations or interests • Missing comparison group for personality traits	• Primarily anecdotal • Small-scale studies of learning outcomes • Missing a comparison group • Challenges measuring skills	• No studies of careers
Collective Gap: No inclusion of practicing engineers			
Selected Contributions	• Extended expectancy-value theory beyond gender differences in engineering • Demonstrated that socially engaged engineers claim, "I am an Engineer AND" with engineering values and additional, broader values	• Used experiential learning theory to compare experiences in engineering activities beyond formal education • Created measurements for technical and professional skills • Demonstrated higher professional skills without loss of technical skills among socially engaged engineers	• Applied a theory of meaningful work to investigate socially engaged engineers' careers • Demonstrated differences in socially engaged engineers' broad career interests, experiences, and career skills • Warned the field about females' disillusionment about socially engaged engineering careers and challenges finding meaningful work
Collective contribution: Provided first large-scale, empirical data with a comparison group to characterize and understand socially engaged engineers from students to practicing engineers			

Contributions to Theory

As an exploratory study, this research was not grounded in one specific theory, but rather, the research made use of several different theories to explain the findings. Chapter 2 used motivational theories that explain individuals' career choices, namely, social cognitive career theory (Lent et al. 1994) and expectancy-value theory (Eccles 1994). Previously, both of these theories had been applied largely to studies of gendered differences within engineering; however, this chapter applied them to study differences between EWB-USA members and non-members and demonstrated that this theory is useful for understanding socially engaged engineers beyond solely gender differences. By providing a comparison group of non-EWB-USA member engineers with which to compare traits of socially engaged engineers, this chapter filled the literature gap recognized by Carberry (2010). Chapter 3 used experiential learning theory (Kolb 1984) to create a framework for comparing learning experiences between EWB-USA members and non-members, specifically by comparing learning in their engineering activities. This framework can be used in future studies to understand how experience in various engineering activities influences learning outside of formal education environments. Through the use of item-response theory and the Rasch model (Rasch 1960), this chapter filled the need for more tangible ways to measure the challenging professional ABET learning outcomes (Shuman et al. 2005) and for more empirical data on learning outcomes of socially engaged engineering activities. Chapter 4 applied a theory of meaningful work (Pratt and Ashforth 2003; Wrzesniewski 2003) to analyze the career expectations and experiences of engineers, previously missing from literature. This chapter illustrated that meaningful work is a valuable lens for understanding socially engaged engineers because it provides an important link to engineers' fit or alignment with engineering, which Chapter 2 flagged may be less sure for socially engaged engineers. Instead of only comparing career interests and experiences, this critical lens helped to highlight warnings about potential misalignment with the current engineering field.

Each main body chapter of this dissertation contributes a description of socially engaged engineers; however, altogether, they contribute to a theory that begins to explain why the population of socially engaged engineers is growing. I consider this to be a theory of personal and vocational misalignment. Historically, engineering has aligned with the values of a particular group pushing political, military, and corporate agendas (Lucena 2005; Riley 2008; Seely 2005), which has left women and minorities on the fringe (Eisenhart et al. 1998; Tonso 2007), has equated engineering with science (Lucena 2005; Seely 2005), and has valued a particular way of thinking and learning (Bernold et al. 2007; Downey et al. 2006). Socially engaged engineering offers an opportunity for engineers who may not have aligned with the historical perspectives of engineering to find their sense of belonging (alignment, fit, identity, fulfillment, etc.) within engineering. In their socially engaged engineering activities, these engineers find expression for their altruistic values, their strengths interfacing between society and technology, and their broad career goals; they convey a message of, "We are engineers AND more." These findings suggest that more diverse engineers find alignment with engineering in their socially engaged engineering activities and theorize that to prepare a more diverse, altruistic, and broadly skilled population, the engineering field should make cultural adjustments that better align with the socially engaged engineers in this study. Although readers are invited to interpret these findings and determine their own cultural adjustments for the field, I offer a few suggested adjustments for engineering education and the engineering workplace following the contributions to practice in the next section.

Another contribution from this body of work offers preliminary theory from which socially engaged engineering programs can grow and develop. As mentioned throughout the body chapters, there are myriad terms used to describe similar engineering activities, which I have named socially engaged engineering. Although the terms are similar, they do not necessarily agree on which aspects of socially engaged engineering are most necessary or most important for courses, programs, and organizations to include. This research did not address this question directly; however, these findings begin to highlight that it is the social engagement component of these programs that must be stressed. Gender balance and youth, although found to be significant in this research, were not enough to explain differences among EWB-USA members and non-members. Participation in professional engineering organizations was also not enough to eliminate the differences between EWB-USA members and non-members. In addition, international experiences and engineering project experiences, although significantly higher for EWB-USA members than non-members (see results in Appendix D), were also not sufficient to explain differences between the two groups. What remains is the social component—the connection to people and communities. In other words, collectively, the group expresses, "We are engineers AND socially engaged." Although additional research could investigate this topic further, I believe that these findings offer initial theory as to what aspect of socially engaged engineering is most important to include—the social engagement.

CONTRIBUTIONS TO PRACTICE

I developed several tools to conduct the research that can be used by other researchers. For instance, the qualitative coding dictionary, survey scales and survey items can be used by other researchers in qualitative, quantitative and mixed-methods studies of both engineers and non-engineers. These tools are included in this dissertation in Appendices B and C. The regression models (included in Appendix D) can also be replicated or extended by other researchers as tools for adding a comparison group to studies of socially engaged engineers (or similar groups such as learning through service engineering students by Carberry 2010) and for comparing other populations. In Chapter 3, I used item response modeling through the Rasch model (Rasch 1960) to create scales of perceived technical and professional skills based on learning outcomes from ABET (ABET 2011) and the Center for the Advancement of Scholarship on Engineering Education (Center for the Advancement of Scholarship on Engineering Education 2005). These scales produced estimated scores for technical and professional skills that were used in multiple linear regression models for this research and could be used in other statistical analyses in future research. The methods used to create these scores from the survey items are detailed in Appendix D.

Additional practical contributions come from application of these findings. First, this research showed that those engineers engaged with EWB-USA do indeed exhibit certain traits that the engineering profession is seeking. Chapter 2 showed that some of these engineers are drawn to engineering schools and workplaces due to programs like EWB-USA, and Chapter 3 suggested that engineering service involvement such as EWB-USA contributed to learning professional skills. These contribute evidence for administrators to encourage and support socially engaged engineering activities as a tool for both recruitment and broader education. Although evidence for the value of learning through service and project based service learning as pedagogy exists (Bielefeldt et al. 2010), this data provides an understanding of the population of engineers drawn to such programs, which Bielefeldt et al. (2010) suggested would help better understand the value of such experiences by controlling for biases within the population of engineers who self-select for such experiences. These findings also contribute evidence to programs such as EWB-USA that support their mission statement and could be used to promote the organization and assist fundraising efforts. Chapter 4 demonstrated potential tensions that socially engaged engineers may face in their careers and outlined recommendations to multiple stakeholders within engineering including EWB-USA, engineering faculty, employees, students, and employers. These recommendations contribute practical suggestions that can help the larger engineering profession adjust to a population of engineers capable and motivated to provide better global engineering solutions.

What types of adjustments are possible? Here I offer some suggested adjustments for both engineering education and the engineering workplace. Within engineering education, I believe that the field should embrace the prediction that, “a new interdisciplinary thrust of engineering can be expected to emerge, what can perhaps be called engineering for development” (Bugliarello 2010 p. 59). This “thrust” has already arrived, whether or not universities have created a formal department. In fact, the lack of a formal department for this type of engineering highlights another suggested adjustment for engineering education: break down the silos that separate the disciplines. Broad, global, socially responsible engineers are needed (National Academy of Engineering 2004; Sheppard et al. 2008), and the body of knowledge for this new type of engineer does not yet exist. Engineering education should respond by imagining new paradigms for broad, global, socially engaged engineering classes and programs and challenge the existing structures that have neglected engineering for social justice and peace (Riley 2008; Vesilind 2005) to better incorporate social engagement in engineering in the curricula. Part of this adjustment includes moving beyond a discourse about recruitment and retention strategies and moving into a discussion of educating the full person to help each student find his or her sense of belonging. The findings from this research suggest that engineering education will continue to see a rise in students with altruistic motivations to study engineering, broad personality traits, interests and skills, and diverse backgrounds and goals that should be embraced by engineering programs, administrators and faculty. Practically, these are large adjustments that will take extensive time and effort, and I am not the first to suggest such changes (Lucena 2005; Seely 2005); however, I believe that the data presented in this dissertation adds a solid, empirically based contribution to inform educational reform efforts in engineering towards more socially engaged engineering.

Similar adjustments can be made in the engineering workplace to embrace socially engaged engineering and work towards more broad, global, and socially responsible engineers and engineering solutions. It is in the workplace that the engineering solutions impacting society come to life; therefore, it is here that leaders should recommit to the foundation of engineering as a service profession and foster this type of meaningful purpose among employees. Recruiters and employers can contribute to cultural adjustments by valuing the attributes of socially engaged engineers and hiring these young graduates; however, they should be mindful of the warnings raised in Chapter 4 to help them find meaningful work. Specifically, workplace leaders can begin to change engineering workplace culture by providing support structures for socially engaged employees that include providing support for or continuing support for the socially engaged engineering activities that employees partake in beyond the workplace, allowing for employee flexibility to find personally meaningful work, and highlighting the social components of engineering projects. I believe socially engaged employees will find a better sense of belonging at their workplace with these support structures because they embrace employees' desires to contribute to pressing societal challenges. Practicing engineers can also influence engineering culture by requesting such support structures and by challenging the existing dichotomy between social and technical dimensions of their work to incorporate holistic and socially responsible views that value the knowledge of those historically excluded from engineering. These changes will not come easily, but this research highlights the importance of advocating for such changes to adjust current engineering culture.

Limitations and Future Research

Limitations are a natural consequence of any study, and this research is no exception. The primary limitation is the use of EWB-USA members as proxies for socially engaged engineers. Although this context was chosen due to its large size and prominence in the engineering service community, and although multiple methods, theoretical frameworks, and statistical controls aided generalizability, the focus on EWB-USA was still a limitation, and future work should incorporate those involved with more socially engaged engineering activities to understand the extent of the results' generalizability. Future work could also investigate the extent to which these results are consistent among international EWB organizations.

Another important limitation of this work was its one-sided focus on socially engaged engineering. Part of the definition of many service learning or community engagement programs includes a two-pronged focus: teaching the learners and providing for the recipients or the "community" (Swan et al. 2014). Because the focus of this study was to characterize and understand the population of socially engaged engineers, incorporating the community recipients' side was not within the scope of this study; however, I do not want to neglect this important limitation. Understandably, such activities have been criticized for this neglect (Riley 2008; Schneider et al. 2008; Vandersteen et al. 2009), and many opportunities exist to better understand the recipients' side in future research on socially engaged engineering.

The qualitative research methods presented other limitations. Because the intent of the research was to explore a relatively unstudied topic, the qualitative data was collected without a strong theoretical framework to guide the interview questions. Now that we have thorough understanding of these engineers, a framework such as expectancy-value theory (Eccles 1994), which has been well-operationalized in engineering education research (Matusovich et al. 2010), could be applied more directly to further validate these findings. As with any data collection, researcher bias also interfered with the qualitative data phase. Although the research team did our best to minimize that bias by positioning ourselves as objective outsiders uninvolved with EWB-USA or other engineering organizations involved in this study, our engineering backgrounds, our interest in socially engaged engineering, our femininity, and our whiteness naturally carried biases that may have influenced participants' responses or the objectivity of the analyses. This limitation opens doors for future research to be carried out by other, different researchers, such as educational anthropologists, to further validate the findings. (See Appendix E for additional discussion of my personal bias and lessons learned in the research.)

Additional limitations were due to the quantitative research methods. Naturally, quantifying people's attributes is a limitation because people are dynamic and complex. Constructs such as personality traits and skill levels cannot be measured in the positivistic sense and must be approximated using pragmatic tools (such as the process detailed by Wilson 2005). Therefore, the scales used in this survey were limited by the assumptions that their values reflect real constructs within individuals in the sample population. Based on this research, opportunities exist to create and validate scales such as skill sets, needed career skills, career roles, and workplace fit. In addition, regression models were limited by the available control variables. For example, socioeconomic status was not included as a variable in the survey; therefore, regression models could not control for this variable in the analyses. All possible control variables or demographic differences are impossible to control for; however, future research could continue to explore what other variables may differ between EWB-USA members and non-members to expand the variables explored in this study.

One such variable suggested for further study is engineering discipline. Chapter 2 found that intrinsic motivations to study engineering differed between mechanical and civil engineers rather than by EWB-USA membership, and Chapter 3 showed that ASME members perceived themselves to have higher technical skills than non-ASME members; however, this was the extent to which engineering disciplines were separated in this research. Previous research has found that attitudes towards social responsibility differed by engineering disciplines among civil, environmental, and mechanical engineering students (Canney 2013). Because the majority of EWB-USA's projects focus primarily on civil and environmental engineering, and in light of the previous literature and initial findings from this research, differences between EWB-USA members and non-members may be related to engineering disciplines. My research primarily treated engineers as a homogenous group, which could be better parsed by engineering discipline in future research.

In addition to the future work resulting from limitations in this study, there are several other opportunities to expand the research presented in this dissertation. For example, this research presented a large-scale study that took a snap shot of current engineering students and practicing engineers. Another approach could follow a smaller sample of engineering students over time as they move into the working roles through a longitudinal, ethnographic approach to this topic, similar to educational researchers' approaches (Stevens et al. 2008; Tonso 2007). I believe that this approach would contribute valuable findings of personal tensions and growth as socially engaged engineers' transition into the workplace.

Additional important future research topics stem from where this research stopped. One such topic asks, how big is this population of socially engaged engineers? This research cannot answer this question because the sampling was not random among a large population of engineers;

however, to emphasize the value of these findings, it will be important to approximate the size of the socially engaged engineering population. Using rough estimates of US engineering students and the US engineering workforce (National Science Board 2014; National Science Foundation 2013), approximately 2% of engineering students and 0.2% of working engineers are involved with EWB-USA; however, socially engaged engineers extend into many other organizations and programs. Although this would be a difficult task, quantifying the size of this population would help emphasize the importance of these results.

Another topic for future research stemming from this dissertation asks, are these engineers more willing and better able to address pressing global engineering challenges? This research was based on assumptions from literature that claimed engineering challenges around the globe could be better solved by diversifying the engineering population and broadening their skill sets (National Academy of Engineering 2002, 2004; Sonnert 1999). These findings characterize socially engaged engineers; however, they do not address the assumption that these engineers actually better address the challenges facing engineers. Although my close interaction with these engineers throughout this research leads me to believe that this population actually does better address complex global engineering challenges, research targeting this topic would help demonstrate that the assumptions in literature were valid and would further clarify the importance of supporting cultural changes in engineering more in line with socially engaged engineers.

The final future research topic that I propose expands upon my initial research question. I asked *how* EWB-USA members and non-members differ, but another important question asks, *why* are these two populations different? Are socially engaged engineers born with different traits, interests, skills, etc., or are they shaped by certain life experiences that have changed their traits, interests, skills, etc.? Canney and Bielefeldt (2014) have developed an initial framework for understanding how engineers' sense of personal and professional social responsibility develop separately and then merge into a connected sense of social responsibility. Such theories can contribute to this understanding whether or not personal and vocational alignment takes place differently among socially engaged engineers. This topic is important to consider because of the misalignment noted in the results from this research between socially engaged engineers and the current engineering culture. For example, this research proposed that socially engaged engineers describe themselves as "We are engineers AND socially engaged"; however, the public perception of an engineer that has been pushed by the NAE (2008a) is one that makes a *difference in the world*, engineers' codes of ethics (e.g., ASCE 2014) place the *public* as its top concern, and engineering work naturally includes both technical and social dimensions (Stevens et al. 2014). Somehow, there is a disconnect between the definitions of what an engineer is (sociotechnical) and the qualified descriptions of an engineer in this research (I am a *socially engaged* engineer), where social engagement is perceived to be an addition to engineering. This disconnect should be understood further through additional research into *why* socially engaged engineers exist as a subset of the larger engineering population that should be socially engaged itself.

Closing Direction & Hopes

The current time presents a pivotal junction for the future of this growing population of socially engaged engineers. One potential future, for which I am hopeful, includes this growing population building its critical mass and creating a wave of cultural change in engineering that supports a broader version of the engineer and allows for more creative solutions to critical engineering challenges facing society (such as those listed in (National Academy of Engineering 2008b; United Nations 2013). However, this future is not certain, and such large-scale change is difficult. The National Academy of Engineers (2008a) has been trying to change the public image of the engineer to one that makes a global difference, but the stereotype of an applied scientist persists (Stevens et al. 2014). Engineering education has seen a rise of programs and organizations in line with socially engaged engineers' interests and passions (see list of such programs in (Lucena and Schneider 2008), but these opportunities are still available at a minority of institutions. Several engineering companies have increased their support of EWB-USA and similar activities, but the military and corporate agendas dominating engineering industry are difficult to reshape (Lucena 2005; Riley 2008; Seely 2005). A wave of cultural change in line with socially engaged engineering will take the passions of individual engineers, educators, and employers to create widespread change.

My hope for this dissertation is that it will help to spur these cultural changes within engineering. I hope that it will inform decisions about creating and supporting organizations such as EWB-USA and similar socially engaged engineering programs; I hope that it will create awareness about cultural biases in engineering beyond solely gender or ethnic minorities, but also about socially conscious and broad-minded engineers; and I hope that it will help engineers reconcile their sense of belonging in the engineering profession where the discussion moves past retention and into pursuits of meaningful work and personal alignment. I agree with Florman (1976) who believed that engineers are most fulfilled when they work in service to humanity. My ultimate hope for this dissertation is that it would bring peace to those with passions for social engagement looking for belonging in engineering and to those desperately in need of creative engineering solutions that those engineers can provide.

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APPENDIX A: ANNOTATED LIST OF PUBLICATIONS

Journal Articles (published)

Litchfield, K. and Javernick-Will, A. (2014). "Investigating Gains from EWB-USA Involvement." *Journal of Professional Issues in Engineering Education and Practice,* 140(1).
Analyzes open-ended questionnaires from regional conferences for EWB-USA members' responses to what an engineering needs to know, the gaps in their education, and the gains from EWB-USA participation
LINK: http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29EI.1943-5541.0000181

Litchfield, K., Javernick-Will, A., and Paterson, K. (2014). "Exploring EWB-USA Members' Descriptions of Self, Engineers, and their Fellow Members." *International Journal for Service Learning in Engineering*, 9(1), 24–39.
Analyzes open-ended questionnaires from regional conferences for EWB-USA members' responses to define themselves, engineers, and EWB-USA members
LINK: http://library.queensu.ca/ojs/index.php/ijsle/article/view/5258

Conference Proceedings

Kaminsky, J., Casias, C., Javernick-Will, A., and Leslie, C. (2012). Expected Outcomes of a Construction Career: Gender Identity and Engineers without Borders-USA. *2012 Construction Research Congress,* West Lafayette, IN, May 2012.
Analyzes the motivations and expected outcomes of EWB-USA members from the initial focus groups for the qualitative phase of the project

Kaminsky, J., Litchfield, K., Javernick-Will, A., and Leslie, C. (2012). Collaborative Research: Gender Diversity, Identity, and EWB-USA. *2012 American Society of Engineering Education Conference*, *NSF Grantees' Poster Session*, San Antonio, TX, June 2012.
Poster session to explain grant and its progress at ASEE conference

Litchfield, K. and Javernick-Will, A. (2012). Perceptions of Engineering Identity: Diversity and EWB-USA. *2012 Frontiers in Education Conference*, Seattle, WA, October 2012.
Initial results from open-ended responses from regional conferences

Litchfield, K. and Javernick-Will, A. (2013). Exploring Motivations for Engineers Without Borders-USA. *2013 Engineering Project Organizations Conference*, Winter Park, CO, July 2013.
Analyzes the motivations for engineering and EWB-USA from all of the focus group and interview participants

Litchfield, K. and Javernick-Will, A. (2013). A New Vision: Changed Engineering Outcome Expectations through EWB-USA. *2013 Frontiers in Education Conference*, Oklahoma City, OK, October 2013.
Work in progress paper that presents initial trends from comparing career outcome expectations from all focus group and interview participants

Litchfield, K., Javernick-Will, A., Knight, D., and Leslie, C. (2014). Collaborative Research: Gender Diversity, Identity, and EWB-USA. *2014 American Society of Engineering Education Conference*, *NSF Grantees' Poster Session*, Indianapolis, IN, June 2014.
Poster session to explain grant's progress at ASEE conference

Litchfield, K., Javernick-Will, A., Knight, D., and Leslie, C. (2014). Distinguishing Engineers of the Future: Comparisons with EWB-USA Members. *2014 American Society of Engineering Education Conference*, Indianapolis, IN, June 2014.
Results from the pilot survey at CU Boulder for all of the survey questions comparing EWB-USA members and non-members

Litchfield, K., Javernick-Will, A., and Knight, D. (2014). "Education Without Borders: Exploring the Achievement of ABET Learning Outcomes through Engineers Without Borders-USA." *2014 American Society of Engineering Education International Forum*, Indianapolis, IN, June 2014.
Results from the pilot survey at CU Boulder focused on ABET learning outcomes between EWB-USA members and non-members

Knight, D., Litchfield, K., and Javernick-Will, A. (2014). "Engineers Without Borders: An Empirical Investigation of Member's Defining Characteristics." *2014 Frontiers in Education Conference*, Madrid, Spain, October 2014.
Presents an exploratory CHAID analysis on the pilot survey data

Journal Articles (under review)

Litchfield, K. and Javernick-Will, A. (n.d.). "Professional Advantage: A Mixed-methods Comparison of Technical and Professional Skills among Engineers Involved and Uninvolved in Engineering Service." *Journal of Engineering Education.*
Compares technical and professional learning outcomes between EWB-USA members and non-members

Litchfield, K., and Javernick-Will, A. (n.d.). "'I am an Engineer AND': A Mixed-Methods Study of Socially Engaged Engineers." *Journal of Engineering Education.*
Compares personality traits and motivations between EWB-USA members and non-members

Working Papers

Litchfield, K., and Javernick-Will, A. (n.d.). "The Miner's Canary: Warnings from Socially Engaged Engineers' Search for Meaningful Work."
Compares students' career expectations and practicing engineers' career experiences between EWB-USA members and non-members

APPENDIX B: QUALITATIVE METHODS

This appendix provides further details about the qualitative methods used in my dissertation including the pilot focus groups and interviews, open-ended questionnaires, and final focus groups and interviews.

PILOT FOCUS GROUP QUESTIONS

Because this research aimed to understand a relatively unstudied population, qualitative data collection began with an exploratory approach along a few themes of interest including identity, motivations, expected outcomes, curriculum, and gender. The list of questions in Table B-1 guided the pilot focus groups; however, discussion was allowed to extend beyond the topics listed in the table when they arose following Spradley's (1979) semi-structured approach to interviews. Separate but similar guides were used for EWB-USA members and non-EWB members, but the guides have been combined in Table B-1 where questions or comments unique to EWB-USA members are italicized.

Focus groups consisted primarily of three parts: opening exercise, group discussion, and group voting (delineated by horizontal lines in Table B-1). To minimize the influence of "group think," we began each focus group (and some interviews early on) with a private exercise using the open-ended questionnaire forms discussed in the next section. This step allowed individuals to think about certain discussion topics prior to the group discussion. Following the group discussion, poster-size paper was used to list words or phrases describing engineering or EWB-USA work (depending on the specific focus group), and participants were asked to discuss the list and vote on the most and least important aspects. This phase was used to generate more discussion about engineering and EWB-USA; however these responses were not analyzed directly.

Table B-1: Pilot focus group and interview guide

Question/prompt		Mapping/theme
Start with private exercise (open-ended questionnaire forms):		
Blue Box	My description of myself	Identity
Green Box	My description a typical engineer	Identity- Engineer
Yellow Box	My description of typical members of EWB-USA	Identity-EWB
Orange Box	Why you became an engineer	Motivation-Engineering
Purple Box	What does an engineer need to know*? (Why you joined EWB)*	Motivation-EWB
Pink Box	Used for voting *(Biggest gains from EWB experience)*	Outcomes- EWB
Please introduce yourself *and tell us why you joined EWB*		Motivation-EWB
Why did you become an engineer?		Motivation-Engineering
What differences exist between how you describe yourself and a typical engineer?		Delta Identity and Engineering Identity
What do you think engineers need to do and know?		Identity/Outcomes- Engineering
What do you want to do/be?		Outcomes &/or Identity
How do you see engineering supporting who you are or want to be?		Outcomes &/or Identity
What gaps were missing in your education?		Curriculum focus
If you had in-country EWB-USA experience, what do you wish you had known?		Curriculum focus
How do you spend your time outside of the classroom/work?		Motivations, other time
Are you a member of any other organizations?		Other time
If yes, what is your biggest gain from your organizational *(or EWB)* experience?		Motivations
Describe what, if anything, your organizational involvement *with EWB* means to your engineering career.		Outcomes_Career
Describe any important relationships you have formed with other people *because of EWB.*		Outcomes_Relationships
Describe any mentor-mentee experiences you have had *because of EWB.*		Outcomes_Mentoring
Describe any experiences you may have had with networking *because of EWB.*		Outcomes_Networking
How do you spend your time outside of the classroom and/or work?		Motivations, other time
Here are some things that some people think about engineers *(or EWB).*		
Do any of them resonate with you?		Outcomes or Identity
What needs to be added?		
Please vote for the two most and least important aspects on your paper.		
EWB tends to have about twice as many women as the average engineering setting. What do you think about this?		Gender and EWB
Are any of you involved with SWE? Why or why not?		Gender & EWB / Identity
Why do you think there are fewer women in engineering?		Gender & Engineering
Of all the things we've discussed, which were most important to you?		
Have we missed anything?		

OPEN-ENDED QUESTIONNAIRE

To generate more understanding about EWB-USA members and their perceptions of themselves and engineering, the research team collected data at seven regional EWB-USA conferences in the fall of 2011. The methods and findings from this phase of the project have been published elsewhere (Litchfield et al. 2014; Litchfield and Javernick-Will 2014); however, Figure B-

1 below shows the open-ended response form, which was a novel data collection method resulting from this research.

Figure B-1: Blank open-ended response form used for data collection

Respondents answered the following questions in the six empty boxes on the form:

Blue: Describe yourself
Green: Describe a typical engineer
Yellow: Describe a typical EWB-USA member
Orange: What do you think an engineer needs to know?
Purple: What, if any, are the gaps in your engineering education?
Pink: What are your biggest gains from your experience with EWB-USA?

Responses to the open-ended questionnaire were coded for emergent themes. A final list of codes and their definitions for the top three and bottom three questions on the form are listed in Table B-2.

Table B-2: Open-ended questionnaire coding dictionary

Descriptions of Self, Engineer and EWB-USA Member	
Adaptable	Easy-going, flexible, changing, evolving, ready for anything, relaxed, open to new experiences, learns from mistakes
Adventurous	Fun, athletic, competitive, on the move, fun-loving, ready to do something, hands-on, new experiences, learn by doing, likes to try new things, fast-paced, active, explorative, spontaneous
Analytical	Likes numbers, math and science, methodical, practical, pragmatic, rational, critical thinker, left-brained, common sense, technical, mechanical, strategic, tinkerer, factual, straight-forward, analyzer, designer, technical knowledge, linear-thinker, logical, structured, quantitative
Confident	Awesome, proud, cocky, not afraid to fail, cool, takes initiative, independent, likes challenge, risk-taker, courageous, takes charge, self-aware, remarkable, entrepreneurial, strong willed, prideful, believes in self, decision maker, capable, headstrong, assertive
Creative	Interesting, innovative, open minded, full of ideas, resourceful, ingenuity, forward-thinking, adaptive, unbounded, inventor, visionary, dreamer, eclectic, experimental, free-spirited, imaginative, unique, clever
Curious	Loves learning, inquisitive, thoughtful, interested in…, seeker, thinker, asks questions, explorative, eager to learn, observer, pensive, contemplative, questioning
Global Perspective	World changer, cultured, international focus, globally aware, global interest, wants to make difference in world, aware, informed, cares about world, multi-cultural interests, 2nd language
Goal-oriented	Goal focused or goal driven, big picture, achiever, success, task-oriented, committed, wants change, leader, committed or dedicated to something specific, make impact, results based, authoritative, has a plan, focused on…, outcome/solution focused, sense of accomplishment, opportunistic, go-getter, wants to implement projects, direct, productive, entrepreneur, type A
Humanitarian	Caring, helper, kind, loves people, giving, make difference, serve, compassionate, volunteer, wants to make things better and improve society, philanthropic, concerned, generous, selfless, conscious, "do-gooder", make positive impact on/help society, meeting needs, impact others, wants to do things right, altruistic, welcoming, looking to do something that matters, socially aware, community driven, concerned, empathetic, nurturing
Introvert	Quiet, shy, laid-back, socially conservative, cold, reserved, non-engaging, not or anti-social, self-conscious
Motivated	Focused, driven, hardworking, ambitious, dedicated, persistent, good work ethic, persevering, won't quit, willing to work, trying to gain skill, empowered, disciplined, diligent, determined, tenacious, devoted
Narrow	Dry, bad communication, not creative, close-minded, rigid, inflexible, serious, hard-headed, bland, odd, uncaring, can't spell, only focused on technical aspects, boring, insensitive, unaware, self-absorbed, stubborn, impatient, naïve, emotionless, poor social skills, black or white, desk worker, by the book, can't dance, selfish, nerdy, awkward, goofy, weird, socially awkward, square, lame, creepy, odd, quirky, glasses, bad jokes
Optimistic	Joyful, happy, hopeful, positive, idealistic, encouraged, cheerful, content
Organized	Organized, detailed, meticulous, thorough, OCD, good time management, perfectionist, efficient, timely, precise, exacting, optimizing, consistent, neat, planner
Outgoing	Friendly, funny, energized, social, loud, extrovert, interactive, charismatic, outspoken, personable, witty, perky, welcoming
Passionate	Wants to be meaningful, wants change, loves life, excited, enjoys engineering, inspired, enthusiastic, eager, wants to make impact, driven to…, desire to…, hungry to…,
Problem Solver	Problem solver, likes puzzles, diagnostic, investigator, finds solutions, makes things work, decipherer, calculating, creates solutions
Respectable	Loyal, good friend, trustworthy, dependable, humble, honest, responsible, patient, listener, accepting, professional, understanding, genuine, sincere, principled, reliable, modest
Smart	Intelligent, educated, knowledgeable, studious, intuitive, academically focused, always thinking, brainy, strong minds, good student, quick thinker, wise, bright, learned
Well-rounded	Interdisciplinary interests, team player, multidisciplinary interests, collaborative, versatile, diverse interests, any background, works well with people, cooperative, balanced

What engineer needs to know, education gaps, and gains from EWB-USA

Awareness of Engineering Impact	Impact or effects of work, knowing the work matters, looking at big picture, seeing the value of work, meaning behind work, purpose as an engineer, implications of work and progress, how engineering impacts society, how can impact world, how work relates to life, engineering philosophy, learning how I can help, understanding global engineering, humanizing engineering work, how to be a good engineer, seeing the implications of the work
Creativity	Innovative, outside box, thinking quickly, vision, open-minded, room to explore, individuality, unconventional solutions, new ideas
Experience and Application	"Real world" problems, understanding, service learning opportunities (like EWB), link to classes, put into practice, implementation, practicality, examples, specifics, hands-on work, projects, design practice, exposure, interactions, field work, relating knowledge, filling in gaps, using skills, understanding project challenges, project completion
Global Perspective	Foreign language, culture, diverse perspectives, life outside of US, wider perspective, diversity, world vision, world understanding, expanded world view, thinking internationally, understanding global issues, global awareness, cultural experience, new people and lifestyles of culture, cultural awareness or appreciate, seeing how others live, exposure to new countries, working in different cultures, experience abroad or overseas, travel
Humanitarian Emphasis	Compassion, how to serve/help, ethics, charity, can make difference, humanitarian purposes, make world better place, integrity, social responsibility, caring, helping others, social justice, giving back, personal connection, having integrity, humanitarian work, community service, fighting poverty, doing good, meaningful work
Interpersonal Skills	Effective communication, public speaking, presenting, technical writing, listening skills, importance of communication, people skills, educating public, social skills, dealing with clients, how to convey ideas to public, able to sell ideas, writing proposals
Networking	Networking, mentorships, teaming with professionals, connections to faculty or clients, making connections, partnerships, contacts
Non-technical Subjects	Humanities, politics, fundraising, economics (costs, sales, finances), life-skills, resume building, anthropology, psychology, soft-skills, liberal arts, social sciences, well-rounded education, health aspects, non-engineering skills, geography, diverse subjects, systems/holistic thinking
Problem Solving	Identify problems, figure out what works, where to get info, obstacles, skills to lead to solution, how to think critically, fix or find problems, how to evaluate problems, troubleshooting, using formulas, investigation, work through adversity, debugging, overcome obstacles and failures, resourcefulness, how to improvise
Project Management	Leadership, organization, operations, time management, know laws and regulations, plan, lead, business knowledge, make decisions, take ownership, be proactive, take responsibility, how to get things done, schedules, deadlines, project scope/process, project coordination, negotiation, budgets
Relationships	Others, people, friends, meeting new/like-minded people, community, social life, community interactions
Societal Awareness	How to help local community, community needs, human factors in design, implementation in unique culture, understand the community being helped, social sides of a problem, understanding client, social-political context, social awareness, community dynamics, context of the problems, another's perspective, seeing societal needs/problems, appreciation for communities
Teamwork	Cooperation, work with others, partner, cross disciplines, group work, team building, collaborative work, multi-disciplinary work, partnerships, camaraderie, community building
Technical Skills	Math, science, engineering field, equations, data collection, analytical skills, use logic, design, engineering, theory, technical info, research, technical knowledge, the trade, STEM, design skills, how to test, engineering background, how to observe, critical thinking, practical knowledge, specific class skills, new technology, expertise, sustainability
Ability to Learn*	Flexibility, adaptation, ask questions, can learn from mistakes, study skills, thinks on toes

Sense of Fulfillment**	Satisfaction, reward of helping, seeing difference/impact, knowing I do meaningful work, something to be proud of, experience my life's passion, doing something that matters, feeling good, sense of accomplishment, self-worth, a cause, fulfillment of goals, contributions
Confidence**	Motivation, inspiration, validation, responsibility, initiative, challenging self, more outgoing, hope, "can be the change", staying enthusiastic, experience with failure, empowerment
Enjoyment**	Had fun, adventure, like what I do, getting involved, excitement, love for engineering, passion, memories, a hobby
Personal Awareness**	Growth, who I am, what I like, new perspective, "reality check", changed my path, changed goals, finding self, new faith, opened my eyes, transformational experience, changed my point of view, changed my life, learned where I fit, vision, why I work hard, vision, revolutionary thinking, life lessons, broadening horizons
Problem Identification*	The problem at hand, understanding the challenges, how to evaluate situation, how to get to root cause, problem constraints, vision to see potential problems, how to recognize problems, what the goals are, how to ask questions, how to choose problem

**Limited to Engineer Needs to Know question; **Limited to Gains from EWB question*

FINAL FOCUS GROUP AND INTERVIEW ADDITIONS

Following eight pilot focus groups, the findings from four of which were published in conference proceedings (Kaminsky et al. 2012), the research team met to discuss additional questions to be added to the interview and focus group guide shown in Table B-1. It was decided that more questions about expected outcomes and involvement with professional engineering organizations should be added, especially questions that could be compared between EWB-USA members and non-members. The additional questions added to the focus group and interview guide are listed in Table B-3.

Table B-3: Additional focus group and interview questions

New Questions	Mapping
What do you or did you think an engineering career would be like?	Expected Outcomes
Do you or did you think you would like being an engineer?	Expected Outcomes
In what ways do you think your experience with EWB will look like or unlike an engineering career?	Expected Outcomes (Students)
Do you intend to stay at your current job? In engineering?	Expected Outcomes (Practitioners)
Have you noticed any major differences between your experience with EWB and other professional engineering organizations, such as ASCE, ASME, SWE, etc.?	Outcomes_Gains
How do you balance your organization *(or EWB)* into your schedules? Have you seen other men or women deterred from getting involved because of the time commitment?	Gender & EWB
Do you see yourself continuing to stay involved with your organization *(or EWB)*?	Outcomes
What does or will continue to drive you to stay involved with your organization *(EWB)*?	Motivations
What are your interests? (Likes, dislikes, free time)	SCCT Model
Did your organization *(or EWB)* impact your career goals? (positively or negatively)	Motivations
What have you gained from your involvement with other organizations (such as ASCE, ASME, SWE, etc.)?	Outcomes_Gains

Qualitative data management

I kept track of qualitative audio recordings and participants using an Excel spreadsheet. As files were transcribed, cleaned, coded at a macro level, summarized, and coded at a micro level, I kept notes on each file's progress. I also kept track of the participants to know which demographics had and had not been reached yet.

All transcriptions, in the form of Microsoft Word files, were uploaded into NVivo 10 software (QSR International 2013). Once the text was in the software, each file was coded to two sets of nodes: one for the participants and one for the content. For example, the entire transcript from an interview was coded to that interviewee's node and was then coded at a macro level for response themes; however, for a focus group, this process was slower. Focus group transcripts were carefully coded to corresponding respondents' nodes using the audio file to ensure that the words were assigned to the proper participant. Once the text was assigned to a speaker, macro coding followed. Coding the text in these two ways allowed me to query for differences by EWB membership, gender, or other attributes assigned to participants, which was an important part of the qualitative results. Table B-4 was exported from NVivo to show each of the 165 qualitative research participants, including those in the pilot focus groups. Notation for the participant ID used the following format: F or M for female or male; E or N for EWB-USA member or non-member, P or S for practitioner or student, and a unique number. Figure B-2 shows the geographic spread of the 24 states represented by the 165 participants.

Table B-4: List of qualitative research participants (n=165)

Qualitative Participant ID	Interview or Focus Group	Focus Group Gender	Engineering Major	State	Travel w/EWB?
F_E_P_1	I	N/A	Chemical	IL	Yes
F_E_P_10	I	N/A	Civil	UT	Yes
F_E_P_12	FG	Female	Unknown	IL	Yes
F_E_P_13	FG	Female	Environmental	IL	Yes
F_E_P_14	FG	Female	Civil	IL	Yes
F_E_P_15	FG	Female	Civil	IL	Yes
F_E_P_2	FG	Mixed	Civil	IA	Yes
F_E_P_3	FG	Mixed	Unknown	MI	Yes

F_E_P_4	FG	Mixed	Civil	TX	Yes
F_E_P_5	I	N/A	Unknown	OH	Yes
F_E_P_6	I	Unassigned	Acoustic	IL	Yes
F_E_P_7	FG	Female	Petroleum	AK	Yes
F_E_P_8	FG	Female	Civil	NY	Yes
F_E_P_9	I	N/A	Civil	CO	Yes
F_E_S_1	FG	Female	Chemical	NH	No
F_E_S_10	FG	Mixed	Civil	PA	N/A
F_E_S_11	FG	Mixed	Civil	PA	N/A
F_E_S_12	FG	Mixed	Unknown	PA	Yes
F_E_S_13	FG	Mixed	Aerospace	OK	Yes
F_E_S_14	FG	Female	Chemical	CO	Yes
F_E_S_15	FG	Female	Environmental	CO	No
F_E_S_16	FG	Female	Civil	CO	No
F_E_S_17	FG	Mixed	Civil	CO	Yes
F_E_S_18	FG	Mixed	Environmental	CO	Yes
F_E_S_19	FG	Mixed	Environmental	CO	No
F_E_S_2	FG	Female	Environmental	NH	Yes
F_E_S_20	FG	Mixed	Unknown	CO	Yes
F_E_S_21	I	N/A	Civil	MD	Yes
F_E_S_22	FG	Female	Civil	CA	Yes
F_E_S_23	FG	Female	Civil	MN	Yes
F_E_S_24	FG	Female	Civil	NY	Yes
F_E_S_25	FG	Female	Civil	FL	Yes
F_E_S_26	FG	Female	Unknown	TX	N/A
F_E_S_27	FG	Female	Unknown	MI	Yes
F_E_S_28	FG	Female	Chemical	TX	N/A
F_E_S_29	FG	Female	Unknown	Ohio	N/A
F_E_S_3	FG	Female	Physics	NH	No
F_E_S_30	FG	Female	Chemical	OH	Yes
F_E_S_31	FG	Female	Unknown	AZ	No
F_E_S_32	I	N/A	Civil	CO	Yes
F_E_S_33	I	N/A	Civil	VT	Yes
F_E_S_34	FG	Female	Architectural	WI	Yes
F_E_S_35	FG	Female	Architectural	WI	No
F_E_S_36	FG	Female	Architectural	WI	No
F_E_S_37	FG	Female	Biomolecular	WI	No
F_E_S_4	FG	Female	Unknown	NH	Yes
F_E_S_5	FG	Female	Civil	MA	Yes
F_E_S_6	FG	Female	Civil	MA	N/A
F_E_S_7	FG	Female	Civil	MA	Yes
F_E_S_8	I	N/A	Civil	MA	Yes
F_E_S_9	FG	Mixed	Architectural	PA	No
F_N_P_1	I	N/A	Unknown	CO	N/A
F_N_P_10	FG	Female	Construction	CA	N/A
F_N_P_11	FG	Female	Construction	CA	N/A
F_N_P_12	FG	Female	Mechanical	CA	N/A
F_N_P_13	FG	Female	Construction	CA	N/A
F_N_P_14	I	N/A	Construction	CO	N/A
F_N_P_2	FG	Mixed	Geological	CO	N/A

F_N_P_3	FG	Mixed	Geological	CO	N/A
F_N_P_5	FG	Mixed	Environmental	CO	N/A
F_N_P_6	FG	Mixed	Civil	CO	N/A
F_N_P_7	FG	Mixed	Unknown	CO	N/A
F_N_P_8	I	N/A	Civil	NH	N/A
F_N_P_9	FG	Female	Construction	CA	N/A
F_N_S_1	FG	Female	Civil	NH	N/A
F_N_S_10	FG	Mixed	Mechanical	CO	N/A
F_N_S_11	FG	Mixed	Mechanical	CO	N/A
F_N_S_12	FG	Mixed	Mechanical	CO	N/A
F_N_S_13	FG	Mixed	Chemical	CO	N/A
F_N_S_14	FG	Mixed	Chemical	CO	N/A
F_N_S_15	I	N/A	Architectural	CO	N/A
F_N_S_16	I	N/A	Chemical	CO	N/A
F_N_S_2	FG	Female	Civil	NH	N/A
F_N_S_3	FG	Female	Civil	NH	N/A
F_N_S_4	FG	Female	Civil	MA	N/A
F_N_S_5	FG	Female	Civil	MA	N/A
F_N_S_6	FG	Female	Civil	MA	N/A
F_N_S_7	I	N/A	Civil	MA	N/A
F_N_S_8	FG	Mixed	Aerospace	CO	N/A
F_N_S_9	FG	Mixed	Applied Math	CO	N/A
M_E_P_1	I	N/A	Civil/Environmental	CO	No
M_E_P_10	FG	Mixed	Mechanical	MI	Yes
M_E_P_11	FG	Mixed	Electrical	IL	Yes
M_E_P_12	FG	Mixed	Mechanical	MI	Yes
M_E_P_13	FG	Mixed	Electrical/Computer	KS	No
M_E_P_14	FG	Mixed	Environmental	NH	No
M_E_P_15	FG	Mixed	Civil	CO	Yes
M_E_P_16	FG	Mixed	Aerospace	AZ	Yes
M_E_P_17	FG	Mixed	Unknown	Unknown	Yes
M_E_P_18	FG	Male	Civil	MN	Yes
M_E_P_19	FG	Male	Civil (Water)	Ohio	Yes
M_E_P_2	I	N/A	Mechanical	CO	Yes
M_E_P_20	FG	Male	Electrical	IL	Yes
M_E_P_21	FG	Male	Civil	OR	No
M_E_P_22	FG	Male	Civil	WI	Yes
M_E_P_23	FG	Male	Civil (Water)	KY	Yes
M_E_P_24	FG	Male	Unknown	Unknown	Yes
M_E_P_25	FG	Male	Civil	CO	Yes
M_E_P_26	FG	Male	Civil	CA	Yes
M_E_P_27	FG	Male	Environmental	CA	No
M_E_P_28	FG	Male	Unknown	MA	Yes
M_E_P_29	FG	Male	Environmental	KY	N/A
M_E_P_3	I	N/A	Mechanical	MD	No
M_E_P_4	FG	Male	Electrical	CO	Yes
M_E_P_5	FG	Male	Environmental	CO	No
M_E_P_6	FG	Male	Biomedical	CO	Yes
M_E_P_7	FG	Male	Geological	CO	Yes
M_E_P_8	FG	Male	Civil	CO	Yes

M_E_P_9	FG	Male	Electrical	CO	Yes
M_E_S_1	FG	Male	Civil	NH	No
M_E_S_10	FG	Mixed	Civil	CO	Yes
M_E_S_11	FG	Mixed	Unknown	CO	Yes
M_E_S_12	FG	Mixed	Unknown	CO	Yes
M_E_S_13	FG	Male	Unknown	Unknown	Yes
M_E_S_14	FG	Male	Mechanical	MI	No
M_E_S_15	FG	Male	Electrical	MD	No
M_E_S_16	FG	Male	Electrical	IL	Yes
M_E_S_17	FG	Male	Unknown	TN	No
M_E_S_18	FG	Male	Unknown	FL	No
M_E_S_19	I	N/A	Environmental	CO	Yes
M_E_S_2	FG	Male	Civil	NH	Yes
M_E_S_20	I	N/A	Civil	CO	Yes
M_E_S_21	FG	Male	Architectural	WI	No
M_E_S_22	FG	Male	Architectural	WI	No
M_E_S_23	FG	Male	Architectural	WI	N/A
M_E_S_24	FG	Male	Civil	WI	No
M_E_S_25	FG	Male	Electrical	WI	No
M_E_S_3	FG	Male	Mechanical	NH	No
M_E_S_4	FG	Male	Civil	MA	Yes
M_E_S_5	FG	Male	Civil	MA	Yes
M_E_S_6	FG	Male	Civil	MA	Yes
M_E_S_7	I	N/A	Civil	MA	Yes
M_E_S_8	FG	Mixed	Math/Computer Science	Unknown	Yes
M_E_S_9	FG	Mixed	Electrical	CO	Yes
M_N_P_1	I	N/A	Chemical	CO	N/A
M_N_P_10	FG	Male	Construction	CA	N/A
M_N_P_11	FG	Male	Construction	CA	N/A
M_N_P_12	FG	Male	Mechanical	CA	N/A
M_N_P_13	FG	Male	Electrical	CA	N/A
M_N_P_14	FG	Male	Civil	CA	N/A
M_N_P_15	FG	Male	Civil	CA	N/A
M_N_P_16	FG	Male	Civil	CA	N/A
M_N_P_17	FG	Male	Civil	CA	N/A
M_N_P_18	FG	Male	Civil	CA	N/A
M_N_P_19	I	N/A	Civil	CO	N/A
M_N_P_2	FG	Mixed	Civil (Water)	CO	N/A
M_N_P_3	FG	Mixed	Unknown	CO	N/A
M_N_P_4	FG	Mixed	Unknown	CO	N/A
M_N_P_5	FG	Mixed	Unknown	CO	N/A
M_N_P_6	FG	Mixed	Unknown	CO	Yes
M_N_P_7	I	N/A	Civil	AK	N/A
M_N_P_8	FG	Male	Construction	CA	N/A
M_N_P_9	FG	Male	Construction	CA	N/A
M_N_S_1	FG	Male	Civil	NH	N/A
M_N_S_10	FG	Mixed	Computer Science	CO	N/A
M_N_S_11	I	N/A	Civil	CO	N/A
M_N_S_12	I	N/A	Civil	CO	N/A
M_N_S_2	FG	Male	Electrical	NH	N/A

M_N_S_3	FG	Male	Civil	MA	N/A
M_N_S_4	FG	Male	Civil	MA	N/A
M_N_S_5	FG	Male	Civil	MA	N/A
M_N_S_6	I	N/A	Civil	MA	N/A
M_N_S_7	FG	Mixed	Aerospace	CO	N/A
M_N_S_8	FG	Mixed	Physics	CO	N/A
M_N_S_9	FG	Mixed	Mechanical	CO	N/A

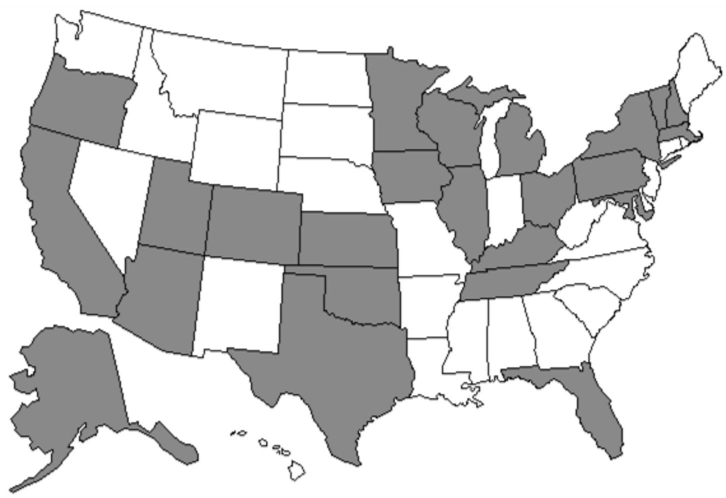

Figure B-2: Geographic spread of qualitative data (24 shaded states)

QUALITATIVE DATA CODING

Macro level coding followed recommendations by Miles and Huberman (1994) to create initial top level codes deductively, based on key variables from the research questions (curriculum, identity, motivations, outcome expectations, and women in engineering). Within each of these five main deductive themes, sub-codes primarily emerged inductively through reading transcriptions. For example, motivations "For Engineering" was a deductive, macro code that contained several sub-codes (e.g. "Family Influence," "Problem Solving," etc.) as specific motivations were mentioned by respondents.

For consistency, a coding dictionary was kept throughout the coding process (as suggested by Miles and Huberman 1994). This dictionary kept track of the nearly 250 codes developed throughout the coding process, and it was used by an undergraduate research assistant to check inter-coder reliability. This dictionary listed all the codes used in the coding process and four additional pieces of information for each code:

1. Whether the code was inductive or deductive (i.e. coming from predefined themes or emerging from the data),
2. Whether the code was interpretive or descriptive (i.e. coming directly from the respondent's words or interpreted by the researchers)
3. A rule for inclusion, or why data would fall into that code, and
4. A definition, or a list of examples of data that had been coded to that specific code.

The undergraduate research assistant used the dictionary to code two focus groups and one interview. Prior to her coding, the two researchers agreed upon certain coding rules to minimize the irrelevant coding discrepancies that the software would find due to its comparison of every character coded. For example, we agreed to code entire paragraphs or "chunks" of the transcript to nodes rather than only a few words of a sentence.

To compare the coding between the two coders, the original NVivo file and the file coded by the undergraduate assistant were merged into one project file. The coding comparison query was then used to compare all nodes across the three double-coded transcripts (listed in the "selected sources" option of the query). Output from the initial coding comparison query showed several nodes with low coding agreement. The two researchers discussed the coding discrepancies within the nodes with low agreement. For example, if a certain node showed that one coder had coded a certain transcript excerpt into the node and the other coder had not, we reread the transcript excerpt and reviewed the nodes that each coder had assigned to the excerpt. We compared the coded nodes with the coding dictionary and discussed our interpreted meanings of both the nodes and the participants' words. Often, upon discussion, one coder agreed that she had misinterpreted the coding dictionary or preferred the other researcher's interpretation of the participant's words. In these cases, the coding dictionary was refined for clarification, and the coding within the merged NVivo file was refined to match the team's decision. If agreement could not be reached, the discrepancy was left in place. After several hours of discussion and refinement, a second coding comparison query was run. This time, the two researchers reached 98.7% agreement across 105 codes (kappa equal to 0.75), with the lowest percent agreement within any one code equal to 84.3%. These results provided sufficient reliability.

As stated in Chapter 1, qualitative analysis was paused here for a time for the survey development and deployment. Further qualitative analysis resumed once the main topics of the dissertation were finalized. At that time, qualitative analysis focused on interviewees as a case-based approach (see next section for summaries) and on recoding previously emergent results to align with coding structures from literature. Through steps of recoding and case-based analyses, the coding dictionary grew to just over 400 codes. This entire dictionary was not practical or useful to share in this appendix, so a reduced version of the final coding dictionary has been included with relevant macro themes, emergent coding, and recoded themes (Table B-5). The dictionary has been formatted to show the five original major topics of interest (bold, italicized and shaded), macro themes (both emergent and deductive in regular font with those broken into micro themes in bold), and micro themes (indented and italicized if definitions or examples are given). Original and recoded macro themes are marked where necessary (e.g. motivations for engineering). Asterisks are used to highlight those codes used for results in specific chapters of this dissertation. For space reasons, rules for inclusion and definitions or examples are combined into one column where definitions or examples are italicized. Rules for inclusion are listed for macro level codes that could be or were broken down further (several micro codes were not relevant to the final dissertation topics), and definitions or examples are listed for the micro level codes used in analyses in the dissertation.

Table B-5: Reduced coding dictionary

Code Name	Code Type	Rule for Inclusion	Definition or Examples (Italics)
Curriculum	--	--	--
EWB filling gaps	Emergent, interpretive	Talk about EWB filling in gaps that people were missing in their engineering education (either explicit or implicit)	
EWB Gaps	Emergent, interpretive	Talk about engineering education gaps from or within EWB (explicit or implicit)	
Filled gaps by co-op or other	Emergent, interpretive	Talk about engineering education gaps that were filled by either co-op or some other group or individual experience (explicit or implicit)	
Gaps	Deductive, descriptive	Answers to the question about gaps in their eng. education or other places gaps are mentioned	
Positives	Emergent, interpretive	Talk about the parts of engineering education that people liked and enjoyed	
Problems	Emergent, interpretive	Talk about the parts of engineering education that people did not like or wish were different	
Supporting Goals	Deductive	Answers to the question about how engineering is supporting goals	
Identity	--	--	--
Community Service*	Deductive	Talk about experience doing or not doing community service	
Engineer	Deductive	Talk about the traits of a typical or non-typical engineer	
Needs to know	Deductive; descriptive	Answers to questions about what an engineer needs to know	
No typical engineer	Emergent	Talk about there being no such thing as a typical engineer	
Non typical engineer	Emergent	Traits or characteristics describing someone who is not a typical engineer (as noted by the talker)	
Typical Engineer	Deductive	Traits or characteristics describing a typical engineer	
Typical is changing	Emergent, interpretive	Talk about how the idea of a typical or stereotypical engineering is changing	
EWB	Deductive	Talk about the traits of an EWB member, typical or not	
Self*	Deductive	Talk about an individual: their major, their characteristics, their likes and dislikes, their activities	
Activities*	Deductive, descriptive	Answers to questions about what activities people like to do	
I am not typical*	Deductive, descriptive	Answers to the question where people say they are not typical	
Why I am not typical*	Deductive, descriptive	Reasons people give for not being typical (personal)	
I am typical*	Deductive, descriptive	Answers to the question where people say they are a typical engineer	
Why I am typical*	Deductive, descriptive	Reasons people give for being typical (personal)	
Mentor for EWB	Deductive, descriptive	Place to tag if someone is an EWB mentor	
Organizations*	Deductive, descriptive	Answers to questions about what other organizations people are involved in	
Orgs vs. EWB	Deductive, descriptive	Comparisons people make about EWB and other organizations	
Motivations	--	--	--
EWB impacting eng. motivations	Interpretive	Talk about how EWB has impacted motivations to stay in or leave engineering (explicit or implicit)	
For Engineering (Original)	Deductive, descriptive	Answers to questions about why people went into or stay in engineering (may also come up later in interview)	
Camps or experiences	Emergent, descriptive	*High school classes, programs, summer camp, going to worksites, travel, example of building something, presentations by others*	

Combine natural fit and satisfaction	Emergent, descriptive	*Combines two previous nodes: Want to know how things work, naturally better at math and science, personality, gravitated towards it, good at it; what I love, fits my interests, made sense, because of my skills, feels good, pride in work, rewarding, meaningful, makes me feel alive, love what I do, worth it, my work matters, satisfying*
EWB or EWB-like	Emergent, descriptive	*EWB made person stay in or enter engineering, development work*
Family member	Emergent, descriptive	*Family member pushing for engineering, engineering profession in family*
Help others	Emergent, descriptive	*Contribute, create change, can help solve problems, socially driven, making a difference, improve community, "do good," change the world; impact society*
Interest in subjects	Emergent, descriptive	*Environmental science, astronaut, enjoy learning the subject, architecture, construction, buildings, technical things, computers (specific interests)*
Just happened	Emergent, descriptive	*Process of elimination, randomly picked; fell into, process of elimination, stumbled in*
Like to tinker	Emergent, descriptive	*Hands-on, taking things apart, building things, Legos, like to design*
Math and Science	Emergent, descriptive	*Mention math and/or science (liked it or good at it)*
Opens doors	Emergent, descriptive	*Opportunities, directly applicable, applicable skills, engineering as foundation for different job, job opportunities, dynamic/flexible options, project variety, there's a demand for it, career to fall back on, growth (career versus day to day work)*
Other	Emergent, descriptive	*Non-social, not English, not as creative for architecture, good and bad days, not just math get to apply it, learn new every day, stay busy, stubbornness, not business, unsure, to prove a point*
Problem solving	Emergent, descriptive	*Like problem solving, finding practical solutions, finding the "why," like the challenge*
Salary or job security	Emergent, descriptive	*Job prospects, benefits of career, good way to make money, reliable career*
Teacher mentor others	Emergent, descriptive	*Role-model, somebody suggested engineering, friends are engineers*
Work Environment	Emergent, descriptive	*Involved in interesting research/projects, variety of projects, like being on the field instead of in an office, people I work with, diversity in work*
For EWB	Deductive, descriptive	Answers to question about why people went into EWB (may also come up later in interview)
Another similar experience	Emergent, descriptive	*School trip, volunteering, Habitat for Humanity, Air Force, other travel, rotary, Peace Corps*
Culture, travel, global awareness	Emergent, descriptive	*Meeting people, fun team, close community, knew people in EWB (specifically)*
Eng. application/experience	Emergent, descriptive	*This is everything I wanted, it allows me to do engineering plus something else I'm interested in*
EWB as combiner of interests	Emergent, descriptive	*Learn more about the world, interested in the international aspect, like to travel, get to travel*
EWB community members	Emergent, descriptive	*Professional or real world experience, learn how to build, using skills, implementing projects, design work, mapping, real-world application, fits with engineering interests, makes me a better engineer, can use skills, project management experience, leadership*
Help others	Emergent, descriptive	*Give back, volunteer, contribute, make a difference/impact, make world a better place, humanitarianism*
Interest in sustainability	Emergent, descriptive	*Environmental, sustainable solutions*
Learn more than technical	Emergent, descriptive	*In line with goals for the future, "spoke to me," it clicked, interest in development work, perfect fit, why I did engineering, humanitarian engineer, aligns with passions or values*

Like Social Aspect	Emergent, descriptive	*Interactions with people, socially driven, build relationships, helps others learn, meeting people*
Natural fit	Emergent, descriptive	*Well rounded, diversity of engineers and subjects*
Other	Emergent, descriptive	*Free time, continuing the work of others, credibility, show off, get out of a class for joining, improved self-perception, opportunity, easy to make change within, easy to get involved, Christian faith, well organized group, impact the industry, improve public awareness*
Patriotism	Emergent, descriptive	*Want to improve perceptions about America; we're representing USA*
Professional connection	Emergent, descriptive	*Want to stay connected to profession, want to join an engineering organization, want to network or meet other engineers, resume builder*
Practitioner involved as student	Emergent, descriptive	*Straightforward*
Recruited	Emergent, descriptive	*Friends, teachers, web-site, student newsletter, presentation, wife, co-worker*
Solve unique problems	Emergent, descriptive	*Finding solutions to problems, finding a better or unique solution*
Worthwhile activity	Emergent, descriptive	*Rewarding, big impact, something to commit to, fulfilling, fun (focus on activity or org.), self-achievement*
For Not EWB	Deductive, descriptive	Answers to question about why people did not go into EWB (non-EWB members)
Other things impacting engineering motivations	Interpretive	Talk about how things like co-op, internships, steel bridge, etc. has impacted motivations to stay in or leave engineering (explicit or implicit)
Reasons for entering eng.	Emergent, descriptive	Code motivations in both the 'for engineering' or 'for EWB' codes and one of these four nodes if their motivation is clearly a reason for entering or staying so we can do cross comparisons
Reasons for entering EWB	Emergent, descriptive	
Reasons for staring in eng.	Emergent, descriptive	
Reasons for staying in EWB	Emergent, descriptive	
Reasons for leaving eng.	Emergent, descriptive	Talk of wanting to leave engineering
Reasons for leaving EWB	Emergent, descriptive	Talk of wanting to leave EWB
What should not motivate EWB members	Emergent, descriptive	Talk about people being against others joining EWB for the 'wrong' reasons *Travel, resume, career advancements and networking, improved self-perception*
Engineering Motivations (Recoded)*	Deductive, descriptive	Recoded responses to "For Engineering" original nodes based on Sheppard et al.'s (2010) motivations; Only responses for entering engineering, not staying or leaving
*EWB or EWB-like**	Deductive	*Person chose to enter engineering b/c of EWB or development work*
*Family member**	Deductive	*Family member pushing for engineering, engineering profession in family*
*Help others**	Deductive	*Give back, volunteer, contribute, make a difference, make world a better place, focus on humanitarianism, make an impact*
*Intrinsic Behavioral**	Deductive	*Combines previous emergent nodes: Like to tinker, math and science, problem solving*
*Intrinsic Psych**	Deductive	*Combines previous emergent nodes: Natural fit or satisfaction, interest in subjects*
*Other**	Deductive	*Combines previous emergent themes without a natural fit into new themes (e.g. camp experiences, being unsure or saying it "just happened" or was random, not liking English)*
*Salary or job security**	Deductive	*Job prospects, benefits of career, good way to make money, reliable career, like the work environment*

*Teacher mentor others**	Deductive	*Role-model, somebody suggested engineering, knew other engineers*
Outcomes	--	-- --
EWB impacting eng. expected outcomes	Interpretive	Talk about how EWB has impacted their expectations about what an engineering career will or could be like (explicit or implicit)
EWB impacting identity	Interpretive	Talk about how EWB is impacting their identify as a person or as an engineer (highly implicit for now)
EWB impacting learning or skills	Interpretive	Talk about how EWB is impacting their learning and engineering skills (similar to their gains from the organization, but more implicit and specific to learning
EWB impacting work	Interpretive	Talk about how EWB is impacting how they work or what they like to work on at work
Expected outcomes of engineering career	Deductive, descriptive	Answers to the questions about expectations of an engineering career
Expected outcomes of engineering school	Deductive, descriptive	Answers to the questions about expectations of engineering school
Gains from EWB (Original)	Deductive, descriptive	Answers to questions about what people gained from being involved with EWB; could also come up implicitly, but primarily stick to the explicit answers
Better Engineer	Emergent, descriptive	*Gaining skills to be a better engineer, useful, changed them as an engineer*
Confidence	Emergent, descriptive	*Being equipped, not being discouraged by failure, used to be nervous but is now better at facing similar tasks*
Creative Problem Solving	Emergent, descriptive	*Finding solutions, New techniques, designing something, how to approach problems, different mindset, unique challenges, sustainable solutions, solve real world problems*
Enjoyment	Emergent, descriptive	*Work is fun, it is amazing, it is cool, enjoyed the experience*
Experience and Application	Emergent, descriptive	*Doing a real project, exploring different parts of engineering, project implementation, exposure to real world engineering, professional experience, hands-on work, applying EWB skills, how to work well with others, building blocks for later career*
Global Perspective	Emergent, descriptive	*Overcoming or learning about cultural differences, awareness, different solutions for different countries, relating across cultures, shapes world view, cultural perspective (on gender, education, etc.), international perspective on engineering*
Helping others	Emergent, descriptive	*Contributing to community, making a difference, volunteering, helping people, positive impact, benefiting the community, teaching*
Make impact	Emergent, descriptive	*Make a difference, positive impact, eng. for change, see the benefits of projects, helping society*
Inspiration	Emergent, descriptive	*EWB helps one read into something bigger or better, passionate*
Leadership	Emergent, descriptive	*EWB makes things happen, how to work with people, running projects*
Learning beyond class	Emergent, descriptive	*new techniques, solutions not learned in classes, professional experience, practical experience, bridges gaps in education, outside of regular curriculum*
Non-tech skills	Emergent, descriptive	*Political science, Spanish, fundraising, community awareness, communication, well-rounded, awareness, multidisciplinary, inter-cultural, project management experience, budgeting, writing documents/grants, public speaking, management skills*

Opportunities	Emergent, descriptive	*Opportunity: to manage project/leadership, adventure, network, apply skills, get involved in engineering process, to learn*
Other	Emergent, descriptive	*No career gains, remaining cool under pressure and making snap decisions, sustainable solutions*
Personal Awareness	Emergent, descriptive	*Using EWB to find out if they want to do EWB-type stuff for life, learn a lot about oneself, revelations about current job, aware of issues, find meaning, shaped world-view, internal benefits, EWB changed me*
Problem Identification	Emergent, descriptive	*Defining the problem, understanding of the project*
Professional Development	Emergent, descriptive	*Resume builder, seeing development as a career, something employers want to see, professional skills, opens doors, networking, helped in the job market, prepared for interviews, EWB provides a real-world job situation,*
Project Management	Emergent, descriptive	*Working on deadlines, working on a team, manage finances, real-world job situation*
Relationships	Emergent, descriptive	*Classmates, communities, co-workers, diversity, EWB members, groups, faculty friends, meeting new people, mentors, networking, people like me, professional community*
Satisfaction	Emergent, descriptive	*Improved self-perception, feeling positive, find meaning, feeling better, "makes you sleep better at night," rewarding*
Societal Awareness	Emergent, descriptive	*Think about the social economic and cultural impacts, international awareness, considering cultural dynamics*
Teamwork	Emergent, descriptive	*Learning how to work with people, community, group effort, partnership, exchange of skills*
Travel	Emergent, descriptive	*Going abroad*
Understanding of Engineering	Emergent, descriptive	*Seeing different parts of engineering, learning the fundamentals of engineering, seeing work that can be done in professional career, exposure to real-world engineering, practical experience, engineering with a cultural/international perspective, non-technical things that are still part of engineering, understanding projects*
Organizational Gains (Recoded)**	Deductive, interpretive	Recoded responses to gains from organizational involvement to fit into ABET or personal themes
*Learning Outcomes***	Deductive, interpretive (interpretive b/c people did not respond using a specific ABET outcome)	Answers to questions about learning gains from organizational involvement coded to an ABET (2011) or CASEE (2005) outcome (also from other parts of interview (e.g. storytelling))

*A apply knowledge***	Deductive, interpretive	*Coding based off ABET (2011) and CASEE (2005) definitions of learning outcomes (see Table 3-1)*
*B experiments and data***	Deductive, interpretive	
*C system to meet needs***	Deductive, interpretive	
*D multi-disciplinary teams***	Deductive, interpretive	
*E solve problems***	Deductive, interpretive	
*F ethics***	Deductive, interpretive	
*G communication***	Deductive, interpretive	
*H impact in context***	Deductive, interpretive	
*I lifelong learning***	Deductive, interpretive	
*J contemporary issues***	Deductive, interpretive	
*K use skills***	Deductive, interpretive	
*L manage and finance***	Deductive, interpretive	
*M multi-disciplinary systems***	Deductive, interpretive	
*N diversity appreciation***	Deductive, interpretive	
*O work ethic***	Deductive, interpretive	
*Personal Gains***	Emergent, descriptive	Gains from organizational involvement that do not fit neatly into an ABET outcome (may be coded into multiple themes)
*Confidence***	Emergent, descriptive	*Being equipped, not being discouraged by failure, used to be nervous but is now better at facing similar tasks*
*Enjoyment***	Emergent, descriptive	*The projects/work is fun, it is amazing, it is cool, enjoyed the experience*
*Inspiration***	Emergent, descriptive	*EWB leads into something bigger or better, passionate, helps push beyond limits, gives me energy for my work*
*Leadership***	Emergent, descriptive	*Learn how to make things happen, learn how to manage people (usually an explicit mention of the word leadership)*
*Personal Awareness***	Emergent, descriptive	*Helped learn about future career interests, learned a lot about oneself, revelations about current job, aware of issues, find meaning, shaped world-view, internal benefits, [activity] changed me or opened by eyes*
*Professional Development***	Emergent, descriptive	*Resume builder, something employers want to see, professional skills, opens doors, networking, helped in the job market, prepared for interviews, practice in a real-world job situation*
*Relationships***	Emergent, descriptive	*Classmates, communities, co-workers, diversity, EWB members, groups, faculty friends, meeting new people, mentors, networking, people like me, professional community*
*Satisfaction***	Emergent, descriptive	*Improved self-perception, feeling positive, find meaning, "makes you sleep better at night," rewarding, fulfilling*
*Well-rounded***	Emergent, descriptive	*Chance to try a lot of new experiences, makes me a more well-rounded person (usually explicit use of "well-rounded"*

Other Gains (Original)	Deductive, descriptive	Gains people mention from things other than EWB such as an internship or when people are asked specifically about the relationships they gained in school
Other things impacting eng. expected outcomes	Interpretive	Talk about how other things such as co-op have impacted their expectations about what an engineering career will or could be like (explicit or implicit)
Prompted answers	Descriptive	Code answers to questions in here that are given due to prompting (such as about relationships or networking gains); can query these ones out later
Workplace views of EWB	Emergent, descriptive	Talk about how a workplace or school either is or is not supportive of EWB activities
Reasons for staying/leaving engineering (Recoded)***	Deductive, interpretive (interpretive b/c did not ask directly about calling or non-calling)	Recoded responses from motivations for engineering (staying or leaving) recoded to align with meaningful work theory themes
*Calling****	Deductive, interpretive	Work as a calling due to the people or the work (Pratt and Ashforth 2003)
*The people****	Deductive, interpretive	*Like the work environment, like the people I work with; like working with people*
*The work****	Deductive, interpretive	*Enjoy learning new skills, like the day to day tasks, wanting to help people, help in general, or help the earth*
*Non calling****	Deductive, interpretive	Work as a non-calling due to work as a job or as a job or as a career (Wrzesniewski 2003)
*Can make money****	Deductive, interpretive	*Like my job because I make good money, I want to have job security*
*Climb ladder****	Deductive, interpretive	*Like to move towards management, like upward mobility*
*Means to achieve other goals****	Deductive, interpretive	*Means to have a family, buy a house, or pursue other interests*
*Tension****	Emergent, interpretive	Responses that don't fit into calling or non-calling (emergent macro theme of tensions)
*Adjust job or work****	Emergent, descriptive	*Have worked to make job align better with interests or values; had to be self-promoting at work to move up; I want to change the industry*
*EWB mesh****	Emergent, descriptive	*Staying at job because allowed or able to do EWB on the side; EWB helps them have good perspective at work; EWB makes it possible to stay at work*
*Leave to work with people****	Emergent, descriptive	*Wants to be at a job with more interaction with people; is considering leaving job to work with people more (e.g. ministry, development)*
Student Goals***	Deductive, descriptive	Students' responses to questions about their future goals or work plans (can come up later in interview too)
*Community Development****	Emergent, descriptive	*International development, community development, NGO work, Peace Corps, research related to development, working in developing communities, work for a non-profit*
*Engineering****	Emergent, descriptive	*Plans to get an engineering job, water consultant, work in industry, career in aerospace, work on mechanical systems, work in design, unsure where exactly but want to get a job in engineering, work in construction management, etc.*
*EWB****	Emergent, descriptive	*Explicit mentions of wanting to do EWB or "something like EWB but paid" as a career*
*Find some volunteer or meaningful outlet****	Emergent, descriptive	*Desires to be useful in work, to find a "meaningful outlet," to keep up volunteering, to be a "professional volunteer"*

*Grad School****	Emergent, descriptive	*Interest in graduate school as a possible or definite next step*	
*Help People****	Emergent, descriptive	*I want to change the world, I have always wanted a job to be able to help people, I want to work with people or have an impact on people, do service*	
*International****	Emergent, descriptive	*Mentions of the words international or global or overseas, etc. when speaking about future career goals or plans.*	
*Management****	Emergent, descriptive	*Desires to work in management*	
*Not Engineering****	Emergent, descriptive	*Explicit desires to pursue careers outside of engineering; wouldn't take and engineering job if offered one right now*	
*Policy or Government****	Emergent, descriptive	*Interest in policy, politics or government*	
*Teaching****	Emergent, descriptive	*Interest in teaching (engineering or not)*	
*Unsure****	Emergent, descriptive	*Unsure about future plans, "don't' know," still a freshman or sophomore, "time to figure it out," not exactly sure yet*	
*Use Engineering****	Emergent, descriptive	*Not sure that I want to do engineering, but I plan to use engineering somehow (e.g. in policy, in development work, combine with MBA, combine with some other interest)*	
Women and Engineering	--	--	--

*Note: *code used in results in Chapter 2; **code used in results in Chapter 3; ***code used in results in Chapter 4*

CASE-BASED ANALYSES

To analyze the qualitative data using a more holist approach, a case-based methodology was used to investigate the interviewees. Each interviewee's transcript (n=27) was reread to better understand the individuals along the emergent themes of interest including personality traits, motivations, engineering identity, career intentions, and organizational involvement. Two members of the research team reviewed each interviewee and held working meetings to discuss and summarize each case. The results of the summarizing are shown in table B-6. Note that the motivations, following those from literature (Sheppard et al. 2010), are labeled with a P for primary and an S for secondary, which were labeled based on the researchers' interpretations. Many participants listed multiple motivations for studying engineering, which is why this approach was taken.

Table B-6: Summary of interview cases for variables of interest

ID	Personality	Engineering Identity	Career goals/intentions	Financial	Family	Social Good	Mentor	Intrinsic Psych.	Intrinsic Beh.	EWB	Outside school/work Involvement
				Motivations for engineering							
FEP1		Typical	Engineering/teaching			P		P			Non-engineering
FEP10			Engineering				P		P		N/A
FEP5		Typical							P		Non-engineering
FEP6	Extraversion, curious, patient	Atypical				S	S		P		Non-engineering
FES21		Doesn't think typical exists	Engineering (EWB on side)					P		S	N/A
FES32	Openness to experience	Atypical	Engineering (EWB-like)				S			P	Non-engineering
FES33	Openness to experience		Engineering (EWB-like)			S	P		P	S	Non-engineering
FES8	Active		Engineering (EWB-like)						P	P	Engineering (Co-op)
MEP1	Active	Typical	Engineering						P		Non-engineering
MEP2	Active, openness to experience	Atypical	Engineering						P		Non-engineering
MEP3	Extraverted	Atypical	Engineering (with people)	S					P		Non-engineering
MES19			Engineering (EWB-on side)		S	S			P		Engineering
MES20	Extraverted	Atypical	Engineering (international)		S	P			S		Non-engineering
MES7		Atypical	Engineering (EWB-like), teach						P		N/A
FEP9		Atypical	Engineering (EWB)							P	Non-engineering
FNP1		Typical	Engineering		P						Non-engineering
FNP14	Good communicator	Atypical	Engineering						P		Engineering
FNP8	Analytical, introverted, goal-driven, strong opinions	Typical	Engineering				P		S		Engineering
FNS15	Extraverted	Atypical	Engineering	S	P		P		S		Engineering
FNS16	Extraverted	Atypical	Engineering	P	P			S			Non-engineering
FNS7	Bilingual, travel, openness to experience	Atypical	Engineering	S	S	S			P		Engineering
MNP1		Typical	Engineering	S	P			S			Non-engineering
MNP19	Extraverted	Atypical	Engineering, retirement			S			P		N/A
MNP7	Extraverted	Atypical	Engineering?						P		Engineering
MNS11	Goal-oriented, extreme spots, likes humanities	Atypical	Non-Engineering (pilot) or engineering	S				P			Engineering & Non-engineering

MNS12	Typical		S	P		N/A
MNS6	Typical	Engineering			P	Engineering

Career goals and intentions of each interviewee were also summarized and discussed. Table B-7 was used as a summarizing tool to help understand the career goals of students and the career intentions of practitioners for Chapter 4 of the dissertation.

Table B-7: Summary of interview cases for career interests

Identifier	Pseudonym in CH4	Brief Career Summary	Engineering Field	Other	State	EWB Travel?
FES8		Would love international development career; EWB changed her goals and companies she considers	Civil	Co-op experience	MA	Yes
FES21	Elena	Wants to work in development to help people back in her home country; EWB impacted her grad program choice	Civil	Grad student; Bolivian	MD	Yes
FES32	Erin	Wants to combine people with engineering; values learning technical skills first to be able to help people	Civil	EWB President	CO	Yes
FES33		Desire to lead development projects; started her own NGO in Costa Rica and would love that to become her job	Civil	Grad student	VT	Yes
MES7		Started his own political website, wants to teach STEM, wants a break from engineering, but would keep up EWB	Civil	Near graduation; co-op	MA	Yes
MES19	Eric	Goal is to work as an environmental consultant, may keep EWB up in future, but it was mostly a hobby	Environmental		CO	Yes
MES20		Interested in international engineering that can help people; not sure what that will be, but likes engineering	Civil		CO	Yes
FNS7	Nora	Wants to do projects that affect people, work in structural engineering; plans for graduate school	Civil	Co-op experience; ASCE	MA	N/A
FNS15	Nicole	Early in education, but plans to become a project manager in construction	Architectural	SWE; No idea of EWB	CO	N/A
FNS16	Natasha	Young and deciding on engineering still, interested in combining interest in chemistry and food for job	Chemical	Freshman; No idea of EWB	CO	N/A
MNS6		Wants to work in engineering; gained broad exposure in co-op, but not sure which he likes best yet	Civil	Co-op experience; ASCE	MA	N/A
MNS11		Lost interest in engineering, wants to be Air Force pilot or combine passion for snowboarding with engineering	Civil	NSBE	CO	N/A
MNS12		Excited to be making money in a structural engineering job rather than be in school	Civil	Grad Student	CO	N/A

FEP1	Emma	No interest in leaving engineering job, but committed to benefitting society; wants to gain tech. skills to teach later	Chemical	With EWB from beginning	IL	Yes
FEP5	Erica	Content with engineering job, but EWB helps to travel and give back and go beyond the technical side		Mom	OH	Yes
FEP6		Loves her engineering job which is not related to EWB, but keeps up EWB for service, travel, and social aspects	Acoustic	EWB President	IL	Yes
FEP9	Elise	Wants to work for EWB, but struggling with decision to leave job; EWB helps her stay in the job because it's rewarding	Civil	EWB Mentor	CO	Yes
MEP1		Has worked at one engineering firm; sees EWB as a nice way to do something different (give back, be social, have fun)	Civil, Environmental		CO	No
MEP2		Likes producing something as an engineer, but EWB satisfies his sense of adventure and gaining experiences	Mechanical		CO	Yes
MEP3		Likes his job with plans to move into project management; EWB helps network and be social at work and to travel	Mechanical	Two years into career	MD	No
FNP1		Plans to stay in consulting and work into project management; kids in college prevented her from joining EWB		Mom	CO	N/A
FNP8	Noel	Loves her job in transportation; fulfills her interest in helping through mentoring and educational outreach	Civil	Mom	NH	N/A
FNP14	Naomi	Project manager, wants to stay in career long term and become an executive; fulfillment in community projects	Construction	Mom; No idea of EWB	CO	N/A
MNP1		Plans to continue in engineering until he retires	Chemical	Family to support	CO	N/A
MNP7	Nolan	Enthusiastic engineer working in transportation, finds fulfillment in the challenge of engineering	Civil	One year into career	AK	N/A
MNP19	Noah	Near retirement after career, proud of the work he has done for the world which was a desire of his	Civil	Worked over 30 years	CO	N/A

Identifiers used for additional pseudonyms in Chapter 4:

Nancy: FNP11

Elsa: FES30

Easton: MEP11

Elizabeth: FEP7

Nicky: FNP5

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APPENDIX C: SURVEY THEMES AND ITEMS

This appendix contains four components:

1. Table C-1 shares a summary of the themes and items from the final survey. The theme numbers listed in the left most column correspond to the theme numbers listed in subsequent tables in this appendix.
2. Table C-2 shares the sources of the scales used within each survey theme and any changes made to the original scales for both the pilot survey and the final survey.
3. Table C-3 shows the initial qualitative findings, what hypotheses each finding lead to in the pilot survey, and what the final outcome of that hypothesis was following the final survey.
4. The remainder of the appendix shares the final survey items exported from Qualtrics survey software.

Table C-1: Final survey themes and items

Theme No.	Theme	Items or Sub-themes	No. of Items	Type of Data
--	Demographic	Year of Birth	1	Continuous
		Gender	1	Categorical
		Major	1	Categorical
		Race/Ethnicity	1	Categorical
		US Citizen	1	Categorical
		Student or Professional Status	1	Categorical
		Years of Work Experience	1	Continuous
		EWB Membership	1	Categorical
		Years of EWB Membership	1	Categorical
		Participation level EWB	1	Ordinal
		Participation level in engineering service	1	Categorical
		Travel with EWB	1	Categorical
		Family Engineer	1	Categorical
		GPA	1	Ordinal
1	Personality Traits	Agreeableness	2	Likert items (7 point); one reverse coded item for each trait
		Conscientiousness	2	
		Emotional Stability	2	
		Extraversion	2	
		Openness to Experience	2	
2	Community Service Attitudes	Empathy	3	Likert items (7 point)
		Intentions	1	
3	Engineering Motivations	EWB-like	2	Likert items (5 point)
		Family Influence	2	
		Financial	3	
		Intrinsic Behavioral	2	
		Intrinsic Psychological	3	
		Mentor Influence	2	
		Social Good	3	

4	ABET Outcomes	*Technical Skills(combined items below)*	16	*Continuous*
		a: Apply knowledge	3	Likert items (5 point)
		b: Experiments & data	4	
		c: System to meet needs	3	
		e: Solve Problems	3	
		k: Use skills	3	
		Professional Skills(combined items below)	30	*Continuous*
		d: Multi-disp. Teams	3	Likert (5 point for all except items for outcomes I, N, and O which were 4 point)
		f: Ethics	3	
		g: Communication	3	
		i: Lifelong learning	3	
		j: Contemporary Issues	3	
		l: Manage & finance	4	
		n: Diversity appreciation	4	
		o: Work ethic	3	
		h: Impact	2	
		m: Multi-disp. Systems	2	
5	Learning Sources (students only)	Technical Skills	6	Continuous (1-100%)
		Professional Skills	9	
6	Student Experiences	Hands-on application	1	Ordinal (No, yes, yes multiple times)
		Project completion	1	
		Teamwork	1	
		Interdisciplinary teamwork within engineering	1	
		Interdisciplinary teamwork beyond engineering	1	
		Leadership or project management	1	
		Non-technical communication	1	
		Mentors and/or networking	1	
		Travel and/or cultural diversity	1	
		Seeing the social impact of your work	1	
		Facing ethical dilemmas	1	
		Experiences	6	
	Global Experiences	Times Traveled	1	Categorical based on question
		Countries Traveled	1	
		Languages	1	
		Time Lived Abroad	1	
		Global Interest	1	Likert items (5 point)
		Global Knowledge	1	
7	Identity	Consider self as engineer	1	Categorical

8	Career Skills	Problem solving	1	Likert items (5 point)
		Hands-on application	1	
		Teamwork	1	
		Technical skills	1	
		Creativity	1	
		Life-long learning	1	
		Awareness of engineering impact	1	
		Project management	1	
		Interpersonal skills	1	
		Communication skills	1	
		Societal awareness	1	
		Global perspective	1	
		Networking	1	
		Humanitarian emphasis	1	
		Non-technical subjects	1	
9	Career Roles	Engineering design or development	1	Likert items (5 point scale) for students; Categorical (yes or no) for practicing engineers
		Non-profit org. community development	1	
		Teacher in engineering-related subject	1	
		Engineering researcher	1	
		Engineering project management	1	
		Engineering upper level management	1	
		Military engineer	1	
		Public policy, government, or law	1	
		Other than eng. design, research, or management	1	
		Not working full time by choice	1	
		Graduate school within engineering	1	
		Professional degree	1	
	Switching Career Roles	Interest in switching career roles (professionals only)	1	Categorical
	TOTAL QUESTIONS		158	

Table C-2: Pilot survey items and scores compared to final survey

No.	Scales and Modifications for the Pilot Survey: Pilot Survey Measurement Scale & Source	Modification Note	Final Survey
1	Academic Pathways of People Learning Engineering Survey (APPLES) Motivations (Sheppard et al. 2010)	Adding two questions for EWB related motivations	Same as pilot
2	Five Factor Model (Gosling et al. 2003)	Using reduced, 10-item scale	Same as pilot
3	Community Service Attitudes Scale (CSAS) (Shiarella et al. 2000)	Using reduced scale with three of eight original constructs	Reduced items from pilot; dropped for final analysis
4	Student and Faculty Engagement in Engineering Education (Center for the Advancement of Scholarship on Engineering Education 2005)	Using reduced questions for each of the A-O criteria to reduce survey size (from 62 to 45 items)	Same as pilot; grouped by technical and professional skills rather than technical, holistic, and broad skills as in pilot
5	Modified National Engineering Students' Learning Outcomes Survey (NESLOS) (Carberry 2010)	None (only given to EWB-USA members)	Same as pilot
6	Global Competency for Engineers (in development by author and research team)	Pilot instrument embedded within the larger pilot survey	Items reduced to "student & global experiences"; dropped for final analysis
7	Engineering Identity (Zarske 2012) & Career-fit confidence (Cech et al. 2011)	Using their reduced versions, modified language to be inclusive of professional engineers	Changed to one item (Meyers et al. 2012); dropped for final analysis, although confirming of results in Ch.2
8	Codes from open-ended questionnaire (Q.4) (Litchfield and Javernick-Will 2014)	(Pilot data from freshman engineering course)	Same as pilot
9	Five year goals/intentions, modified from APPLES (Sheppard et al. 2010)	Added more options and changed wording to be inclusive of professional engineers	Changed to list of 12 career roles after team brainstorming and three employer interviews

Table C-3: Comparison of survey hypotheses between comprehensives proposal and final results

	Initial Qualitative Findings for Pilot Survey Creation		Final Survey Results
No.	**Qualitative Findings**	**General Survey Hypotheses**	
1	Non-EWB members have more typical motivations and natural interest in engineering subjects, and more family or mentor encouragement	EWB members have weaker intrinsic engineering motivations and family or mentor support	Controlling for other variables, intrinsic and family motivations were equivalent; pro-social motivations that were higher for EWB
2	EWB members describe themselves as being very open and interested in multiple subjects and cultures (from questionnaires)	EWB members have more open and extroverted personalities	EWB members had more open and agreeable personalities, but extraversion was explained by org. involvement in general
3	EWB members have more “helping” community service experience (vs. just volunteering) and express “helping others” as their top motivation for EWB	EWB members have a will have a higher community service attitude as measured by CSAS (gender may be a confounding variable)	This variable was dropped in the final analysis because it was not novel to the field.
4	EWB members and Non-EWB members have comparable technical skills, but EWB members have stronger professional skills, especially at student level	EWB members will have stronger ABET professional skills, but may have equivalent technical skills	This hypothesis was confirmed and was generalizable to engineers involved in engineering service.
5	EWB members gain important professional and personal skills and self-awareness from their EWB experience (significant gains from questionnaires)	EWB members gain more ABET professional skills through their EWB involvement than their course work	This was true but was not discussed in Ch. 2 because the question was only given to students.
6	EWB members often mentioned not identifying themselves as a typical engineer and shared their interest in other disciplines, cultures, languages, and school subjects.	EWB members have more global competency or global awareness than Non-EWB engineers.	The measure of global competency was dropped because further research showed it was a more complex concept to measure than this research allowed for.
7	Many EWB members do not perceive that they ‘fit’ with the typical view of engineering, but they do perceive a ‘fit’ with the EWB-USA organization; some see the profession as changing	EWB members have a weaker engineering identity and career-fit confidence than Non-EWB members	This hypothesis was proven false. Their identities were equivalent. See Ch.2 for “I am an Engineer AND” description of this.
8	EWB members see an ideal engineering career to be something very different from the traditional views, needing more professional skills	EWB members have higher expectations of professional skills needed at an engineering job than Non-EWB members	This was confirmed, see Ch. 4.
9	EWB members have less intentions to pursue a traditional engineering degree; they are less sure of their fit in an engineering career (even more so for the female professional members)	Non-EWB members will show stronger intentions to pursue a traditional engineering career (EWB professional females will struggle more than female students because they have seen reality)	After the pilot study, these questions were asked in a new way to avoid the dichotomy of persistence. EWB members were more interested and experienced in broader career roles; and female disillusionment was found.

Official NSF-REE Survey Items

Q1 Thank you for taking our survey! We realize that your time is extremely valuable, and we sincerely appreciate your input!

The primary purpose of this research is to understand different attributes, motivations, and expectations of engineers and to compare these items based upon membership in different engineering organizations. Your feedback on this study will help to understand some of the pre-education traits, educational experiences, and post-education outcomes of engineers. These results will help to inform recommendations to university and workplace settings to better educate more prepared engineers of the future to help address pressing global challenges.

There are no foreseeable risks to your participation in this survey. The potential benefits include contributions towards recommended changes for the future of engineering education and workplace initiatives.

We anticipate this survey to take you approximately 15-20 minutes. Your participation is voluntary and your responses are confidential; they will not be reported in any manner that will identify you. At the end of the survey, you will have the opportunity to be entered into a raffle for an iPad or a $10 Amazon gift card, providing your thorough completion of the survey. We anticipate the approximate odds of winning an iPad to be 2 in 5,000, and the approximate odds of winning a gift card to be 10 in 5,000.

If you have any questions regarding your participation in this research, you should ask the investigator before participating. If you should have questions or concerns during or after your participation, please contact Kaitlin Litchfield at kaitlin.litchfield@colorado.edu or Dr. Amy Javernick-Will at amy.javernick@colorado.edu.

If you have questions regarding your rights as a participant, any concerns regarding this project or any dissatisfaction with any aspect of this study, you may report them -- confidentially, if you wish -- to the Executive Secretary, Institutional Review Board, 3100 Marine Street, Rm A15, 563 UCB, (303) 735-3702.

This research is sponsored by the National Science Foundation - Research in Engineering Education Program.

- ☐ Check to indicate you have read the statement above and agree to participate in the survey

Q2 Which of these engineering subjects is most related to your educational experience?

- ❍ Aerospace Engineering
- ❍ Architectural Engineering
- ❍ Biological/Biomedical Engineering
- ❍ Chemical Engineering
- ❍ Civil Engineering
- ❍ Computer Science/Engineering
- ❍ Electrical Engineering
- ❍ Environmental Engineering
- ❍ Industrial Engineering
- ❍ Materials and Metallurgical Engineering
- ❍ Mechanical Engineering
- ❍ Other Engineering
- ❍ Non-engineering

Q3 Of the organizations listed below, with which are you involved? (Select all that apply)

	Official member	Involved but not an official member
American Society of Civil Engineers	❍	❍
American Society of Mechanical Engineers	❍	❍
Other professional engineering organization	❍	❍
Society of Women Engineers	❍	❍
Engineers Without Borders-USA	❍	❍

Q4 Are you a student or professional member of your selected organizations?

- ❍ Student member
- ❍ Professional member

Answer If Of the organizations listed below, with which are you involved? (Select all that apply)...

Q5 For each of your selected organizations, please indicate the approximate number of years you have been involved.

	1 year or less	2-3 years	4-5 years	6-7 years	8-9 years	10 years or more
American Society of Civil Engineers	❍	❍	❍	❍	❍	❍
American Society of Mechanical Engineers	❍	❍	❍	❍	❍	❍
Other professional engineering organization	❍	❍	❍	❍	❍	❍
Society of Women Engineers	❍	❍	❍	❍	❍	❍
Engineers Without Borders-USA	❍	❍	❍	❍	❍	❍

Answer If Of the organizations listed below, with which are you involved? (Select all that apply)...
Q6 For each of your selected organizations, please indicate your current level of active participation.

	No active participation	Limited active participation	Moderate active participation	Extensive active participation
American Society of Civil Engineers	❍	❍	❍	❍
American Society of Mechanical Engineers	❍	❍	❍	❍
Other professional engineering organization	❍	❍	❍	❍
Society of Women Engineers	❍	❍	❍	❍
Engineers Without Borders-USA	❍	❍	❍	❍

Answer If Of the organizations listed below, with which are you involved? (Select all that apply) Engineers Without Borders-USA - Official member Is Selected Or Of the organizations listed below, with which are you involved? (Select all that apply) Engineers Without Borders-USA - Involved but not an official member Is Selected
Q7 Have you traveled outside of the US for a project with EWB-USA?
❍ Yes
❍ No

Q8 What is your current level of active participation in an engineering service curriculum, organization, or program similar to, but NOT including, Engineers Without Borders-USA (for example, Engineers for a Sustainable World organization, Engineering Projects in Community Service program, a Humanitarian Engineering minor or certificate program, etc.)?
❍ Not associated with such a program
❍ Associated, but no active participation
❍ Limited active participation
❍ Moderate active participation
❍ Extensive active participation

Answer If What is your current level of active participation in a p... Associated, but no active participation Is Selected Or What is your current level of active participation in a p... Limited active participation Is Selected Or What is your current level of active participation in a p... Moderate active participation Is Selected Or What is your current level of active participation in a p... Extensive active participation Is Selected

Q9 Based on your response to the previous question, with which specific program(s) or organization(s) are you involved?____

Answer If Are you a student or professional member of your selected organizations? Student member Is Selected

Q10 How likely is it that you will be doing each of the following in the next five years?

	Definitely not	Probably not	Not sure	Probably yes	Definitely yes
Working in design or development in industry within your engineering discipline	❍	❍	❍	❍	❍
Working at a not-for-profit organization doing community development work	❍	❍	❍	❍	❍
Working as a teacher in an engineering-related subject (e.g. math, science)	❍	❍	❍	❍	❍
Working as a researcher within your engineering discipline	❍	❍	❍	❍	❍
Working in an engineering firm in a project management role	❍	❍	❍	❍	❍
Working in upper level management at an engineering company	❍	❍	❍	❍	❍
Working in the military as an engineer	❍	❍	❍	❍	❍
Working in a role concerning public policy, government, or law	❍	❍	❍	❍	❍
Working doing something other than engineering design, research, or management	❍	❍	❍	❍	❍
Not working full time by choice	❍	❍	❍	❍	❍
Attending graduate school within engineering	❍	❍	❍	❍	❍
Using the engineering degree as a stepping stone to a different professional degree (e.g. medicine, law, business)	❍	❍	❍	❍	❍

Answer If Are you a student or professional member of your selected organizations? Professional member Is Selected

Q11 Of the options listed below, which roles have you been in since graduating with your engineering degree? You may select as many options as applicable.

- ❑ In design or development in industry within your engineering discipline
- ❑ At a not-for-profit organization doing community development work
- ❑ As a teacher in an engineering-related subject (e.g. math, science)
- ❑ As a researcher within your engineering discipline
- ❑ At an engineering firm in a project management role
- ❑ In upper level management at an engineering company
- ❑ In the military as an engineer
- ❑ In a role concerning public policy, government, or law
- ❑ In a role other than engineering design, research, or management
- ❑ Not working full time by choice
- ❑ As a graduate student within engineering
- ❑ As a student using your engineering degree as a stepping stone to a different professional degree (e.g. medicine, law, business)

Answer If Are you a student or professional member of your selected organizations? Professional member Is Selected

Q12 Of the options listed below (same as previous question), is there a role in which you have interest for switching into? Please select only one option.

- ❍ In design or development in industry within your engineering discipline
- ❍ At a not-for-profit organization doing community development work
- ❍ As a teacher in an engineering-related subject (e.g. math, science)
- ❍ As a researcher within your engineering discipline
- ❍ At an engineering firm in a project management role
- ❍ In upper level management at an engineering company
- ❍ In the military as an engineer
- ❍ In a role concerning public policy, government, or law
- ❍ In a role other than engineering design, research, or management
- ❍ Not working full time by choice
- ❍ As a graduate student within engineering
- ❍ As a student using your engineering degree as a stepping stone to a different professional degree (e.g. medicine, law, business)
- ❍ I have no interest in switching roles

Q13 Do you consider yourself to be an engineer?

- ❍ Yes
- ❍ No
- ❍ In some ways yes, and some ways no

Q14 We list a number of personality traits that may or may not apply to you. Please indicate the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
Extraverted, enthusiastic	❍	❍	❍	❍	❍	❍	❍
Critical, quarrelsome	❍	❍	❍	❍	❍	❍	❍
Dependable, self-disciplined	❍	❍	❍	❍	❍	❍	❍
Anxious, easily upset	❍	❍	❍	❍	❍	❍	❍
Open to new experiences, complex	❍	❍	❍	❍	❍	❍	❍
Reserved, quiet	❍	❍	❍	❍	❍	❍	❍
Sympathetic, warm	❍	❍	❍	❍	❍	❍	❍
Disorganized, careless	❍	❍	❍	❍	❍	❍	❍
Calm, emotionally stable	❍	❍	❍	❍	❍	❍	❍
Conventional, uncreative	❍	❍	❍	❍	❍	❍	❍

Q15 Pretend you are going to volunteer for community service sometime in the next year. In this case, community service is defined as a project in which you would volunteer at least twice a month for a couple of hours and use your skills and knowledge (i.e. more than just a one-time volunteer event). Please indicate the extent to which you agree with the following statements.

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
I feel bad about the disparity among community members	❍	❍	❍	❍	❍	❍	❍
I feel bad that some community members are suffering from a lack of resources	❍	❍	❍	❍	❍	❍	❍
When I meet people who are having a difficult time, I wonder how I would feel if I were in their shoes	❍	❍	❍	❍	❍	❍	❍

Q16 How likely is it that you will participate in a community service project in the next year?

- ❍ Very Unlikely
- ❍ Unlikely
- ❍ Somewhat Unlikely
- ❍ Undecided
- ❍ Somewhat Likely
- ❍ Likely
- ❍ Very Likely

Q17 We are interested in different learning outcomes from your engineering experience (including education, internships, work experience, and extracurricular activities). Please rate your ability to do the following.

	No ability	Some ability	Adequate ability	More than adequate ability	High ability
Use basic scientific principles to analyze the performance of processes and systems	❍	❍	❍	❍	❍
Use basic engineering principles to analyze the performance of processes and systems	❍	❍	❍	❍	❍
Formulate and evaluate mathematical models describing the behavior and performance of systems and processes	❍	❍	❍	❍	❍
Design an experiment	❍	❍	❍	❍	❍
Analyze evidence or data from an experiment	❍	❍	❍	❍	❍
Interpret results of an experiment	❍	❍	❍	❍	❍
Use evidence to draw conclusions or make recommendations	❍	❍	❍	❍	❍
Identify essential aspects of the engineering design process	❍	❍	❍	❍	❍
Apply systematic design procedures to open-ended problems	❍	❍	❍	❍	❍
Design solutions to meet desired needs (within realistic constraints)	❍	❍	❍	❍	❍
Work in teams where knowledge and ideas from many disciplines (business, public policy, engineering, etc.) must be applied	❍	❍	❍	❍	❍
Work in teams where knowledge from many engineering disciplines must be applied	❍	❍	❍	❍	❍
Effectively manage conflicts that arise when working on multidisciplinary teams	❍	❍	❍	❍	❍
Identify problems for which there are engineering solutions	❍	❍	❍	❍	❍
Formulate a range of solutions to an engineering problem	❍	❍	❍	❍	❍
Test potential solutions to an engineering problem	❍	❍	❍	❍	❍
Identify ethical dilemmas in engineering practice	❍	❍	❍	❍	❍
Address ethical issues when working on	❍	❍	❍	❍	❍

engineering problems					
Apply technical codes and standards	❍	❍	❍	❍	❍
Convey technical ideas in writing	❍	❍	❍	❍	❍
Convey ideas verbally	❍	❍	❍	❍	❍
Convey ideas in formal presentations (to engineering and non-engineering audiences)	❍	❍	❍	❍	❍
Estimate the impact of engineering solutions in a societal context (in a particular culture, community, state, nation, etc.)	❍	❍	❍	❍	❍
Estimate the impact of engineering solutions in a global context (including environmental and economic contexts)	❍	❍	❍	❍	❍
Apply engineering techniques (e.g., processes, methods) in engineering practice	❍	❍	❍	❍	❍
Apply engineering skills (e.g., experimentation, matching, programming) in engineering practice	❍	❍	❍	❍	❍
Apply engineering tools (e.g., software, lathes, oscilloscopes) in engineering practice	❍	❍	❍	❍	❍
Manage a team's time to meet deadlines when leading a project	❍	❍	❍	❍	❍
Create and follow a budget when managing a project	❍	❍	❍	❍	❍
Address the business, financial, and market related matters associated with project engineering	❍	❍	❍	❍	❍
Apply interpersonal skills in managing people	❍	❍	❍	❍	❍
Integrate knowledge and skills learned in engineering disciplines other than your specific major	❍	❍	❍	❍	❍
Recognize the need to consult an expert from a discipline other than your own when working on a project	❍	❍	❍	❍	❍
Consider contemporary issues (economic, environmental, political, aesthetic, etc.) at the local, national, and world levels	❍	❍	❍	❍	❍
Estimate how engineering decisions and contemporary issues can impact each other	❍	❍	❍	❍	❍
Use knowledge of contemporary issues to make engineering decisions	❍	❍	❍	❍	❍

Q18 To what extent are you/do you:

	Not at all	Somewhat	Mostly	Always
Set and pursue your own learning goals	❍	❍	❍	❍
Take new opportunities for intellectual growth or professional development	❍	❍	❍	❍
Engage in critical, reliable, and valid self-assessment	❍	❍	❍	❍
Recognize the unique skills, abilities, and attributes of all students/colleagues in your engineering course/practice	❍	❍	❍	❍
Recognize the need for diverse perspectives in solving engineering problems	❍	❍	❍	❍
Comfortable working with engineering clients and colleagues from diverse racial/ethical backgrounds	❍	❍	❍	❍
Comfortable working with engineering clients and colleagues of the opposite gender	❍	❍	❍	❍

Q19 In your engineering work, how often do you do the following? (Think of past year)

	Almost never	Occasionally	Often	Almost always
Take initiative to learn on your own	❍	❍	❍	❍
Seek ways to improve a design or project, even after it has been submitted	❍	❍	❍	❍
Complete your share of tasks on time, when working in teams	❍	❍	❍	❍

Answer If Of the organizations listed below, with which are you involved? (Select all that apply) Engineers Without Borders-USA - Official member Is Selected And Are you a student or professional member of your selected organizations? Student member Is Selected

Q20 Please indicate how helpful your EWB experience was compared to your coursework learning (CL) in enabling you to achieve the following skills. Move the sliding bar to indicate the percent impact from EWB, as compared to coursework learning. Ex. 60% indicates that 60% of a skill was learned through EWB while 40% was learned through coursework.

_______ Apply math, science, and engineering knowledge
_______ Design a system, component, or process to meet desired needs
_______ Design an experiment
_______ Analyze and interpret data
_______ Apply techniques, skills, and modern engineering tools in practice
_______ Conduct (or simulate) an experiment
_______ Communicate effectively with others
_______ Operate in the unknown (i.e. open-ended problems)
_______ Function within a team
_______ Engage in critical, reliable, and valid self-assessment
_______ Persevere to complete an engineering design task
_______ Maintain a strong work ethic throughout an engineering project design
_______ Understand the impact of your engineering design/solution in a societal and global context
_______ Identify potential ethical issues and dilemmas of a project
_______ Recognize the need for life-long learning

Q21 We are interested in knowing why you chose engineering as an area of study. Please indicate below the extent to which the following reasons apply to you.

	Not a reason	A minor reason	A moderate reason	An important reason	An extremely important reason
I think engineering is fun	❍	❍	❍	❍	❍
I like to build stuff	❍	❍	❍	❍	❍
I feel good when I am doing engineering	❍	❍	❍	❍	❍
I like to figure out how things work	❍	❍	❍	❍	❍
I think engineering is interesting	❍	❍	❍	❍	❍
A mentor encouraged and/or inspired me to study engineering	❍	❍	❍	❍	❍
A mentor introduced me to people and opportunities in engineering	❍	❍	❍	❍	❍
Technology plays an important role in solving society's problems	❍	❍	❍	❍	❍
Engineers have contributed greatly to fixing problems in the world	❍	❍	❍	❍	❍
Engineering skills can be used for the good of society	❍	❍	❍	❍	❍
Engineers are paid well	❍	❍	❍	❍	❍
An engineering degree will/would guarantee me a job after graduation	❍	❍	❍	❍	❍
Engineers make more money than most other professionals	❍	❍	❍	❍	❍
My family wanted me to be an engineer	❍	❍	❍	❍	❍
My family would have disapproved if I chose a major other than engineering	❍	❍	❍	❍	❍
Engineers Without Borders or a similar type of work interested me	❍	❍	❍	❍	❍
I wanted to use engineering to do community development projects around the world	❍	❍	❍	❍	❍

Q22 How much do you need/expect to incorporate the following skills in your own engineering career?

	Not at all Important	Somewhat important	Moderately important	Very Important	Crucial
Problem solving	❍	❍	❍	❍	❍
Hands-on application	❍	❍	❍	❍	❍
Ability to work in teams	❍	❍	❍	❍	❍
Technical skills	❍	❍	❍	❍	❍
Creativity	❍	❍	❍	❍	❍
Life-long learning	❍	❍	❍	❍	❍
Awareness of engineering impact	❍	❍	❍	❍	❍
Project management skills	❍	❍	❍	❍	❍
Interpersonal skills	❍	❍	❍	❍	❍
Communication skills	❍	❍	❍	❍	❍
Societal awareness	❍	❍	❍	❍	❍
Global perspective	❍	❍	❍	❍	❍
Networking	❍	❍	❍	❍	❍
Humanitarian emphasis	❍	❍	❍	❍	❍
Non-technical subjects	❍	❍	❍	❍	❍

Answer If Are you a student or professional member of your selected organizations? Student member Is Selected
Q23 In your education, including both inside and outside of the formal classroom, have you had the following experiences within engineering?

	No, never	Yes, once	Yes, multiple times
Hands on application of skills and knowledge	❍	❍	❍
Seeing a project through completion	❍	❍	❍
Teamwork	❍	❍	❍
Interdisciplinary teamwork within engineering	❍	❍	❍
Interdisciplinary teamwork beyond engineering disciplines	❍	❍	❍
Leadership or project management experience	❍	❍	❍
Communication with or to non-technical audiences	❍	❍	❍
Access to mentors and/or networking	❍	❍	❍
Travel and/or cultural diversity	❍	❍	❍
Seeing the social impact of your work	❍	❍	❍
Facing ethical dilemmas	❍	❍	❍

Q24 Please indicate whether or not you have done the following activities. If you have done a certain activity, please select whether or not you have done this once or more than once.

	No	Yes, once	Yes, more than once
Have you traveled to a country that most people would classify as 'developing'?	❍	❍	❍
Have you traveled to a country that does not speak your mother tongue?	❍	❍	❍
Have you held a job in or been a student in a country other than your home country?	❍	❍	❍
Have you worked on an engineering project where you traveled to another country?	❍	❍	❍
Have you worked on an engineering project that took place in another country where travel was not necessarily required?	❍	❍	❍
Have you worked on an engineering project with people from multiple countries?	❍	❍	❍

Q25 How many countries have you traveled to other than your home country?
❍ Never
❍ One other country
❍ 2-5 other countries
❍ 6-9 other countries
❍ 10 or more other countries

Q26 How many times (independent trips) have you traveled to a country other than your home country?
❍ Never
❍ One time
❍ 2-5 times
❍ 6-9 times
❍ 10 or more times

Q27 What is your level of experience in studying about countries or cultures other than your own? Use your own discretion as to what types of courses may count (e.g. language, world geography, international policy courses, etc.)
❍ Never took a course
❍ Took one course
❍ Took multiple courses
❍ Minor or certificate
❍ Bachelor's Degree
❍ Master's Degree or Multiple Bachelor's Degrees
❍ PhD or expert level

Q28 How many languages other than your mother tongue can you speak fluently?
❍ None
❍ 1
❍ 2
❍ 3 or more

Q29 Approximately how long (in total) have you spent time in another country other than your home country?
- ❍ Never
- ❍ 1 to 2 weeks
- ❍ 1 to 2 months
- ❍ About 6 months
- ❍ About one year
- ❍ 2 to 3 years
- ❍ About 5 years
- ❍ 8 or more years

Q30 Overall, how would you rate your:

	Non-existent	Below Average	Average	Strong	Very Strong
Interest in global matters?	❍	❍	❍	❍	❍
Knowledge of global matters?	❍	❍	❍	❍	❍

Q31 Please write in your year of birth.

Q32 What gender do you associate yourself with?
- ❍ Male
- ❍ Female
- ❍ Prefer not to answer

Q33 What is your current working status?
- ❍ Undergraduate student
- ❍ Graduate student
- ❍ Practicing professional
- ❍ Academic
- ❍ Retired
- ❍ Other
- ❍ Unemployed by choice

Answer If What is your current working status? Unemployed by choice Is Selected

Q34 Please share why you have decided to be unemployed by choice.____________________

Answer If What is your current working status? Undergraduate student Is Selected

Q35 What year are you in your undergraduate degree?
- ❍ Freshman
- ❍ Sophomore
- ❍ Junior
- ❍ Senior
- ❍ Fifth year senior or more

Q36 How many years have you worked professionally in an engineering-related field?

Q37 Do any of your immediate family members (i.e. parents, siblings) hold an engineering degree?
- ❍ Yes
- ❍ No
- ❍ Uncertain

Q38 What is/was your approximate college GPA during your engineering studies? (Please estimate on a 4.0 scale)
- ❍ A or A+ (i.e., 3.9 or above)
- ❍ A- (3.5-3.8)
- ❍ B+ (3.2-3.4)
- ❍ B (2.9-3.1)
- ❍ B- (2.5-2.8)
- ❍ C (2.2-2.4)
- ❍ C- or lower (1.9-2.1)
- ❍ Not applicable, no engineering degree

Q39 Are you a citizen of the United States?
- ❍ Yes
- ❍ No
- ❍ Prefer not to answer

Q40 What is your race/ethnicity?
- ❍ American Indian or Alaskan Native
- ❍ Asian or Asian American
- ❍ Black or African American
- ❍ Hispanic or Latino/a
- ❍ Native Hawaiian or Pacific Islander
- ❍ White
- ❍ Other
- ❍ Multiracial
- ❍ Prefer not to answer

Q41 Thank you for completing our survey! If you would like to be entered into our raffle to win either an iPad or one of several $10 Amazon gift cards, please leave your preferred email address. This information will not be connected to your responses, which remain confidential, and it will only be used for raffling purposes.
Email Address:________________________

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APPENDIX D: QUANTITATIVE METHODS

This appendix includes details of the quantitative methods employed in my dissertation. First, a general summary is presented to outline the methods used to import the data from Qualtrics survey software into Stata statistical software. This method was consistent across all three body chapters of the dissertation. Then, methods specific to chapters 2, 3, and 4 are shared in further detail, primarily focusing on the coding used for analyses in Stata. Chapter 3 includes methods used to create scales of technical and professional skills using Construct Map software.

GENERAL DATA MANAGEMENT

Following the close of the official survey, I downloaded the responses from the Qualtrics platform (https://cuboulder.qualtrics.com) into a CSV file. Because one organization's policies did not allow us to collect any identifying information, two surveys were used, one without the final item asking participants for their email if they wished to be entered into our prize raffle. Therefore, responses from the two surveys were downloaded separately and combined into one Microsoft Excel file. The resulting spreadsheet listed each of the 2,896 respondents in its own row with 197 columns, one for each item's response. Any respondents who had skipped the survey items and jumped to the email solicitation for the prize raffle were eliminated, which resulted in 2,882 final respondents. This final list was stored in a file, "Official_NSFREE_Survey_Results_TOTAL FINAL."

From this population, 1,503 participants provided an email address to be part of the prize raffle for two iPad's and twenty $10 Amazon gift cards. Each of these respondents was assigned a number 1 to 1,503, and a random number generator in Excel was used to choose the winners in front of a small audience of research team members to be fair. Winners were emailed electronic gift certificates.

Because this research was focused on EWB-USA, and comparisons were to be made between *engineers* involved and uninvolved with this *US-based* organization, we removed respondents who were not US citizens or who had not studied engineering. This left 2,674 final survey respondents from which all subsequent analyses were based. Table D-1 shares a summary of this final population (note that not all respondents shared their gender or student versus practitioner status. This list of respondents was stored in a new file, "Official_NSFREE_Survey_ Results_REDUCED FINAL."

Table D-1: Summary of official survey respondents by demographics

EWB-USA Members 672				Non-EWB-USA Members 2002			
Females 253		Males 412		Females 418		Males 1559	
Practitioners	Students	Practitioners	Students	Practitioners	Students	Practitioners	Students
91	162	258	153	240	174	1265	277

Once the spreadsheet of respondents was finalized, initial data management began. First, each column, which represented a unique survey item, was labeled with a variable name. For example, the item, "Of the organizations listed below, with which are you involved? (Select all that apply): Engineers Without Borders-USA," was labeled "EWB." Items within a set, such as questions about personality traits, were labeled using the same first letter and a unique identifier to follow. For example, personality items such as being open to new experiences and being extraverted were labeled with the labels P_OPEN and P_EXT. Creating concise and recognizable labels was important to be able to identify the data later in Stata software. This lesson was learned through the pilot survey. All of the variable names and their corresponding survey items were stored in a codebook file for reference.

Once each variable was labeled, some variables needed to be cleaned up. For example, for year of birth, participants were told to write in their year of birth; however, some responses were clearly not correct. Responses such as "198" and "6-Jan" were eliminated because they were unclear, and responses such as "53" and "'992" were corrected (in these cases to 1953 and 1992) based on best judgment. In addition, some variables needed to be recoded. For example, each personality trait included one item that was reverse coded on the 1-7 scale. To recode the these items, the VLOOKUP function in Excel was used (e.g., =VLOOKUP(BA2,{1,7;2,6;3,5;4,4;5,3;6,2;7,1}, 2,FALSE) where BA2 was the cell containing the response to the reverse coded item.)

Following variable clean up, some items needed to be combined. Each personality trait consisted of two items. Using the regularly coded response, and the corrected reverse coded response, the scores for each trait were indexed (sum divided by two) to produce the final personality trait scores. The indexed variables were labeled unique to be able to identify the "combined" variables (e.g., P_C_OPEN, P_C_EXT). Similarly, the motivations scales were indexed from the two or three responses per category. ABET items were combined by letter (for example, the three items about teamwork were combine into the learning outcome (d) "an ability to function on multidisciplinary teams" using the median value. These combined scores were later dropped from analysis in favor of the item response modeling technique described in the Chapter 3 section below. Additional variables were also created for some demographic items using Excel's logic functions. For example, the dichotomous variable for EWB-USA membership ("EWBMEM") was created using the formula "=IF(OR(G2=1,G2=2),1,0)" where column G held responses for whether or not one indicated "official" (=1) or "unofficial" (=2) EWB-USA membership. Another important new variable was "active_max" which took respondents' maximum response to the questions about participation levels (in ASCE, ASME, EWB, SWE or OTHER). Dichotomous variables for none, limited, moderate, and extensive participation were created based on the active_max variable.

Following this data management, a new file was saved to be imported to Stata software. Extra respondent information such as personal email addresses and extra survey information such as question numbers were removed from this file. Using the import feature in Stata, the Excel file was uploaded into Stata software, where the variable labels in the first row were used as variable names for the Stata file. Once the data was uploaded, variables' values were labeled for ease of interpretation using the variable manager window. For example, responses for participants' race were labeled one through nine; however, without a key, these values were unidentifiable. Therefore, the value label "race" was created and assigned to the race variable with the values 1="American Indian," 2="Asian," etc. This file was saved as Stata file "Official EWB survey data.dta," from which all three subsequent chapters' Stata files were created.

Within this main Stata file, initial coding began to rename and create variables needed for analyses. The following is a list of the coding used for this file, specifically to create a dichotomous variable for gender, to create an age variable, and to create a semi-continuous variable for GPA. In Stata, codes that being with asterisks (*) are notes and are not run by the program. I have used these throughout the coding below to provide descriptions. I will not define the Stata commands used in the coding here; however, further information about Stata and its commands can be found at http://www.stata.com/support.

```
*Recode gender variable into female dummy variable
*Note: only 23 people responded gender=3, "prefer not to answer"
gen female=1 if gender==2
replace female=0 if gender==1
label var female "Dummy variable for females"

*Generate age variable from year of birth data
gen age=2014-yob

*Recode GPA to be semi-continuous variable
gen GPA=gpa
replace GPA=3.95 if GPA==1
replace GPA=3.65 if GPA==2
replace GPA=3.30 if GPA==3
replace GPA=3.0 if GPA==4
replace GPA=2.65 if GPA==5
replace GPA=2.3 if GPA==6
replace GPA=1.05 if GPA==7
*drop those with GPA=8 ("unsure")
```

For each chapter, I primarily share the final coding used to produce the results shared in the results and discussion sections of the main body chapters. Additional analyses used to explore the variables and different regression models, are not shown; however, each chapter does include some additional analyses not shared in the main body chapters due to space constraints. These sections of the coding are labeled as "Not included in dissertation" for clarity.

CHAPTER 2

Coding for Chapter 2 consisted of defining a new data set, variable creation, descriptive statistics, diagnostics, and regression analyses. Several additional analyses were run to explore other models such as multinomial logistic regression models with a three-category outcome variable (non-active organization members, active non-EWB organization members, and active EWB organization members), which are not shown here.

```
*Using the "Official EWB survey data.dta" file to create a new file for CH2
*generate new variable for family engineer (dichotomous)
gen fameng=1 if fam_eng==1
replace fameng=0 if fam_eng==2

*Drop missing data for gender, age, GPA, race, family engineer, and personality and
   motivation items
drop if mi(female, fameng, age, mot_c_fam, mot_c_ewb, mot_c_ment, mot_c_beh,
   mot_c_psych, mot_c_fin, mot_c_good, p_c_ext, p_c_agre, p_c_cons, p_c_open, p_c_emo,
   GPA, race)
*179 dropped

drop if GPA==8
*25 dropped (GPA=8 was "unsure")

drop if race==9
*80 dropped (Race=9 was "prefer not to answer")

*DROP EWB_like_part with 3,4,5 for participation level and NOT in EWB (223 people
   dropped, now 2167)
drop if ewber==0 & ewblike_part==3
drop if ewber==0 & ewblike_part==4
drop if ewber==0 & ewblike_part==5
*realized after article submission that this should have been "ewbmem" not "ewber";
   this resulted in an extra 20 people getting dropped that could have stayed in,
   which was not significant enough to change major findings

*generate "minority" dichotomous variable for all races but white (leave "no answer"
   as missing)
gen minority=1 if race==1
replace minority=1 if race==2
replace minority=1 if race==3
replace minority=1 if race==4
replace minority=1 if race==5
replace minority=1 if race==7
replace minority=1 if race==8
replace minority=0 if race==6

*Demographic information, descriptive stats, and tests of comparison
tab female ewbmem, col chi2
tab minority ewbmem, col chi2
tab fameng ewbmem, col chi2
ttest age, by(ewbmem)
ttest GPA, by(ewbmem)

tab female ASCEer, col chi2
tab minority ASCEer, col chi2
```

```
tab fameng ASCEer, col chi2
ttest age, by(ASCEer)
ttest GPA, by(ASCEer)

tab female ASMEer, col chi2
tab minority ASMEer, col chi2
tab fameng ASMEer, col chi2
ttest age, by(ASMEer)
ttest GPA, by(ASMEer)

tab female SWEer, col chi2
tab minority SWEer, col chi2
tab fameng SWEer, col chi2
ttest age, by(SWEer)
ttest GPA, by(SWEer)

*check for Cronbach's alphas for scale reliability for personality items:
alpha p_extr p_ext
alpha p_agrer p_agre
alpha p_consr p_cons
alpha p_openr p_open
alpha p_emor p_emo
*Only extraversion is over 0.70 (0.74, 0.35, 0.52, 0.41, 0.64)

*check for Cronbach's alphas for scale reliability for motivation items:
alpha mot_psyc1 mot_psyc2 mot_psyc3
alpha mot_beh1 mot_beh2
alpha mot_ment1 mot_ment2
alpha mot_good1 mot_good2 mot_good3
alpha mot_fin1 mot_fin2 mot_fin3
alpha mot_fam1 mot_fam2
alpha mot_ewb1 mot_ewb2
*All over 0.70 (0.80, 0.71, 0.85, 0.79, 0.83, 0.68, 0.79)

*generate new dichotomous variables for other org members
gen ASCEer=1 if asce==1
replace ASCEer=1 if asce==2
replace ASCEer=0 if missing(asce)
gen ASMEer=1 if asme==1
replace ASMEer=1 if asme==2
replace ASMEer=0 if missing(asme)
gen SWEer=1 if swe==1
replace SWEer=1 if swe==2
replace SWEer=0 if missing(swe)

*Logistic regression models for personality traits (see Table 2-2)
logit ewbmem female age active_lim active_mod active_ext, or
logit ewbmem p_c_ext female age active_lim active_mod active_ext, or
logit ewbmem p_c_agre female age active_lim active_mod active_ext, or
logit ewbmem p_c_cons female age active_lim active_mod active_ext, or
logit ewbmem p_c_open female age active_lim active_mod active_ext, or
logit ewbmem p_c_emo female age active_lim active_mod active_ext, or

*Logistic regression models for motivations (see Table 2-3)
logit ewbmem female age minority GPA fameng, or
logit ewbmem mot_c_psych female age minority GPA fameng, or
logit ewbmem mot_c_fam female age minority GPA fameng, or
logit ewbmem mot_c_ewb female age minority GPA fameng, or
logit ewbmem mot_c_ment female age minority GPA fameng, or
logit ewbmem mot_c_beh female age minority GPA fameng, or
logit ewbmem mot_c_fin female age minority GPA fameng, or
logit ewbmem mot_c_good female age minority GPA fameng, or
```

```
*Compare results with ASCE
logit ASCEer female age active_lim active_mod active_ext, or
logit ASCEer p_c_ext female age active_lim active_mod active_ext, or
logit ASCEer p_c_agre female age active_lim active_mod active_ext, or
logit ASCEer p_c_cons female age active_lim active_mod active_ext, or
logit ASCEer p_c_open female age active_lim active_mod active_ext, or
logit ASCEer p_c_emo female age active_lim active_mod active_ext, or

logit ASCEer female age minority GPA fameng, or
logit ASCEer mot_c_psych female age minority GPA fameng, or
logit ASCEer mot_c_fam female age minority GPA fameng, or
logit ASCEer mot_c_ewb female age minority GPA fameng, or
logit ASCEer mot_c_ment female age minority GPA fameng, or
logit ASCEer mot_c_beh female age minority GPA fameng, or
logit ASCEer mot_c_fin female age minority GPA fameng, or
logit ASCEer mot_c_good female age minority GPA fameng, or

*Compare results with ASME
logit ASMEer female age active_lim active_mod active_ext, or
logit ASMEer p_c_ext female age active_lim active_mod active_ext, or
logit ASMEer p_c_agre female age active_lim active_mod active_ext, or
logit ASMEer p_c_cons female age active_lim active_mod active_ext, or
logit ASMEer p_c_open female age active_lim active_mod active_ext, or
logit ASMEer p_c_emo female age active_lim active_mod active_ext, or

logit ASMEer female age minority GPA fameng, or
logit ASMEer mot_c_psych female age minority GPA fameng, or
logit ASMEer mot_c_fam female age minority GPA fameng, or
logit ASMEer mot_c_ewb female age minority GPA fameng, or
logit ASMEer mot_c_ment female age minority GPA fameng, or
logit ASMEer mot_c_beh female age minority GPA fameng, or
logit ASMEer mot_c_fin female age minority GPA fameng, or
logit ASMEer mot_c_good female age minority GPA fameng, or

*Compare results with SWE
logit SWEer female age active_lim active_mod active_ext, or
logit SWEer p_c_ext female age active_lim active_mod active_ext, or
logit SWEer p_c_agre female age active_lim active_mod active_ext, or
logit SWEer p_c_cons female age active_lim active_mod active_ext, or
logit SWEer p_c_open female age active_lim active_mod active_ext, or
logit SWEer p_c_emo female age active_lim active_mod active_ext, or

logit SWEer female age minority GPA fameng, or
logit SWEer mot_c_psych female age minority GPA fameng, or
logit SWEer mot_c_fam female age minority GPA fameng, or
logit SWEer mot_c_ewb female age minority GPA fameng, or
logit SWEer mot_c_ment female age minority GPA fameng, or
logit SWEer mot_c_beh female age minority GPA fameng, or
logit SWEer mot_c_fin female age minority GPA fameng, or
logit SWEer mot_c_good female age minority GPA fameng, or

*Compare by major (ME vs. CE)
gen ME=1 if major==10
replace ME=0 if major==4

*drop if ME is missing, create new temporary file to test these models
logit ME mot_c_psych female age minority GPA fameng, or
logit ME mot_c_fam female age minority GPA fameng, or
logit ME mot_c_ewb female age minority GPA fameng, or
logit ME mot_c_ment female age minority GPA fameng, or
logit ME mot_c_beh female age minority GPA fameng, or
logit ME mot_c_fin female age minority GPA fameng, or
logit ME mot_c_good female age minority GPA fameng, or
```

```
*Cohen's d for age and GPA effect sizes:
esize twosample GPA, by(ewbmem) cohensd
esize twosample age, by(ewbmem) cohensd

*NOT INCLUDED IN DISSERTATION: results from identity survey question

*Reorder identity responses where 1=no, 2=some, 3=yes (new variable ID)
gen ID=1 if identity==2
replace ID=2 if identity==3
replace ID=3 if identity==1

*Engineering identity ordinal logistic regression for total, students, and
  practitioners (ewbmem as predictor variable instead of outcome for proper order for
  potential causal argument)
ologit ID ewbmem female age minority GPA fameng, or
ologit ID ewbmem female age minority GPA fameng if svp==1, or
ologit ID ewbmem female age minority GPA fameng if svp==2, or
```

Results from the ordinal logistic regression model for identity showed that EWB-USA members and non-members did not have significant differences in their response to the question, "do you consider yourself to be an engineer?" (response options: yes, no, in some ways yes and in some ways no) controlling for age and gender (OR=0.85, SD=0.11, p=0.212). Age (OR=1.03, SD=0.005, p<0.001), female gender (OR=0.77, SD=0.10, p=0.046), and minority status (OR=0.54, SD=0.08, p<0.001) were significant control variables. Differences were still insignificant when students and practitioners were separated; however, minority status was the only variable significant at the $\alpha=0.05$ level in the student model, and age and minority status were the only significant variables at the $\alpha=0.05$ level in the practitioner model.

Chapter 3

Before using Stata for Chapter 3, Construct Map software (UC Berkeley 2013) was used to create person location estimates on scales of technical and professional skills. Here I describe this process before presenting the code used in Stata. The pilot survey data was used to learn Construct Map software and to practice interpreting its outputs.

To begin in Construct Map software (version 4.6.0), 2,674 "students" were created, one for each of the final survey participants, and 46 "items" were created, one for each of the learning outcomes survey items (see Appendix C for detailed items). Responses for each student were copied into Construct Map from the responses in the Excel file after they were recoded. Recoding was necessary because Construct Map requires that the lowest item score be 0; therefore, the scores in Excel were recoded using the VLOOKUP function. Two item sets were created, one for technical skills and one for professional skills, and each item was assigned to one of the two sets (see Table 3-1 for details). Initially, default calibration options were used, which included the partial credit model option. The Monte Carlo integration method was selected over the Quadrature method based on expert advice. Two separate computations were run, one for the technical skills item set and one for the professional skills items set. Upon running the computation for item parameters for the professional skills estimate, the default 200 maximum iteration limit was reached, therefore, this limit was increased to 500.

Once the item parameters were estimated, several reports were examined, beginning with the item analysis reports. Cronbach's alpha for the technical and professional skills items were 0.94 and 0.95 respectively, indicating strong reliability. In addition, these reports showed that mean ability estimates were increasing with each higher category, which indicated proper function of the scale. The item fit reports graphed the infit mean squares for each item. For technical skills, all but one of the items were within the 0.75 to 1.33 cutoff range, and all of the items for professional skills were within this range (see Figures D-1 and D-2 respectively).

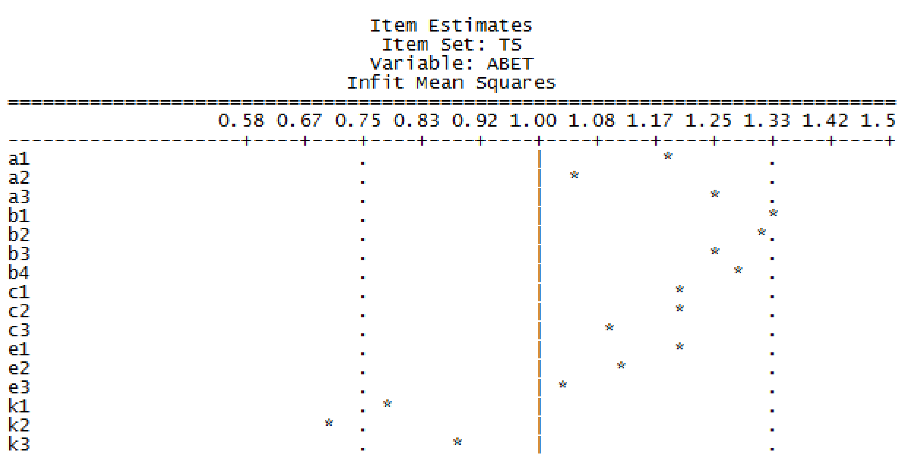

Figure D-1: Construct Map infit mean squares output for technical skills

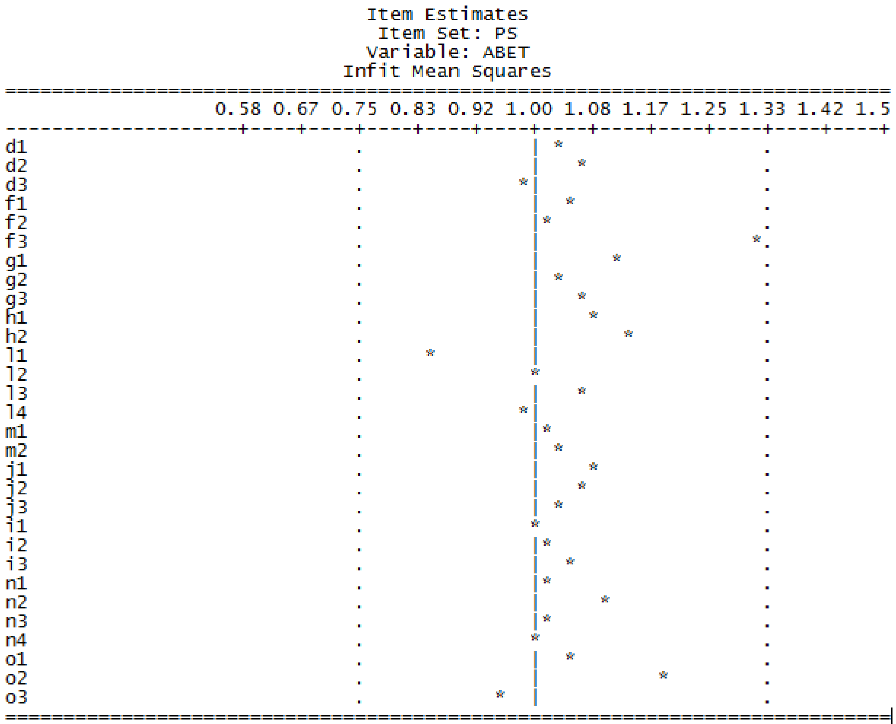

Figure D-2: Construct Map infit mean squares output for professional skills

The ability estimates group report was generated to produce the list of estimated person locations and errors. The output from these reports was exported into an Excel file where the student ID numbers from Construct Map were verified against the survey respondent ID numbers. The survey ID numbers and estimated scores and errors for both technical and professional skills were uploaded to a new Stata file, which was then merged with the existing Stata file for the larger project. The variables were named TSEst, TSError, PSEst, and PSError, respectively.

Once the estimated technical and professional skills scores were uploaded into Stata, coding began for Chapter 3. This coding consisted primarily of some additional variable create, descriptive statistics, pairwise comparisons based on population groups, and many linear regression analyses.

```
*Using the “Official EWB survey data.dta” file to create a new file for CH3

*Drop missing data for gender, age, ABET items, and service participation
drop if mi(female, age, GPA, TSEstimate, PSEstimate, ewblike_part)
*129 dropped
drop if GPA==8
*27 dropped (GPA=8 was "unsure")
*total of 2,518 left (630 EWBers or 25%)
```

```
*create new variable for service folks (not in EWB) "service_noewb"
gen service_noewb=1 if ewbmem==0 & ewblike_part==2
replace service_noewb=1 if ewbmem==0 & ewblike_part==3
replace service_noewb=1 if ewbmem==0 & ewblike_part==4
replace service_noewb=1 if ewbmem==0 & ewblike_part==5
replace service_noewb=0 if ewbmem==1
replace service_noewb=0 if ewblike_part==1

*create variable to combine EWB members with service folks
gen ewborserv=1 if ewbmem==1
replace ewborserv=1 if service_noewb==1
replace ewborserv=0 if ewbmem==0 & service_noewb==0

*variable for nonewb and nonservice
gen noewbnoserv=1 if ewborserv==0
replace noewbnoserv=0 if ewborserv==1

*check for Cronbach's alphas for scale reliability:
alpha abet_a1 abet_a2 abet_a3
alpha abet_b1 abet_b2 abet_b3 abet_b4
alpha abet_c1 abet_c2 abet_c3
alpha abet_d1 abet_d2 abet_d3
alpha abet_e1 abet_e2 abet_e3
alpha abet_f1 abet_f2 abet_f3
alpha abet_g1 abet_g2 abet_g3
alpha abet_h1 abet_h2
alpha abet_k1 abet_k2 abet_k3
alpha abet_l1 abet_l2 abet_l3 abet_l4
alpha abet_m1 abet_m2
alpha abet_j1 abet_j2 abet_j3
alpha abet_i1 abet_i2 abet_i3
alpha abet_n1 abet_n2 abet_n3 abet_n4
alpha abet_o1 abet_o2 abet_o3

*Descriptives & tests of comparison
tab ewbmem
tab service_noewb
tab noewbnoserv
tab female ewbmem, col
tab female service_noewb, col
tab female noewbnoserv, col
summ ZPSEst ZTSEst age GPA, detail
summ ZPSEst ZTSEst age GPA if ewbmem==1, detail
summ ZPSEst ZTSEst age GPA if noewbnoserv==1, detail
summ ZPSEst ZTSEst age GPA if service_noewb==1, detail

corr PSEstimate TSEstimate age GPA
*correlation of TS and PS = 0.69

*Create standardized variables for TS and PS estimates:
egen ZTSEst=std(TSEstimate)
egen ZPSEst=std(PSEstimate)

*Pairwise comparisons
*EWB and service
tab female ewbmem if noewbnoserv==0, col chi2
ranksum age if noewbnoserv==0, by(ewbmem)
ranksum GPA if noewbnoserv==0, by(ewbmem)
ttest ZPSEst if noewbnoserv==0, by(ewbmem)
ttest ZTSEst if noewbnoserv==0, by(ewbmem)

*EWB and Nons
tab female ewbmem if service_noewb==0, col chi2
```

```
ranksum age if service_noewb==0, by(ewbmem)
ranksum GPA if service_noewb==0, by(ewbmem)
ttest ZPSEst if service_noewb==0, by(ewbmem)
ttest ZTSEst if service_noewb==0, by(ewbmem)

*Nons and service
tab female service_noewb if ewbmem==0, col chi2
ranksum age if ewbmem==0, by(service_noewb)
ranksum GPA if ewbmem==0, by(service_noewb)
ttest ZPSEst if ewbmem==0, by(service_noewb)
ttest ZTSEst if ewbmem==0, by(service_noewb)


*Multiple linear regression models
*without any controls
reg ZTSEst ewbmem service_noewb
reg ZPSEst ewbmem service_noewb

*with controls (see results in Table 3-4)
reg ZTSEst ewbmem service_noewb female age GPA
reg ZPSEst ewbmem service_noewb female age GPA

*check for differences between EWB and service
reg ZTSEst service_noewb noewbnoserv female age GPA
reg ZPSEst service_noewb noewbnoserv female age GPA

*check for interaction effects after create new variables
gen ewbmemXage=ewbmem*age
gen service_noewbXage=service_noewb*age
reg ZTSEst ewbmem service_noewb female age GPA ewbmemXage service_noewbXage
reg ZPSEst ewbmem service_noewb female age GPA ewbmemXage service_noewbXage

*check if explained by level of activity
xi: reg ZTSEst ewbmem service_noewb female age GPA i.active_max
xi: reg ZPSEst ewbmem service_noewb female age GPA i.active_max

*check with other orgs
reg ZTSEst ewbmem service_noewb female age GPA SWEer ASCEer ASMEer
reg ZPSEst ewbmem service_noewb female age GPA SWEer ASCEer ASMEer

*NOT INCLUDED IN DIESSERTATION:
tab gc_live ewbmem, chi2 col

xi: reg ZPSEst ewbmem service_noewb female age GPA i.gc_live
```

To check whether or not increased professional skills among EWB-USA members and engineers involved in service activities were explained by more time spent abroad, we compared responses to the item, "approximately how long (in total) have you spent time in another country other than your home country?" between EWB-USA members and non-members . Based on chi-square tests of proportions, EWB-USA members had spent significantly more time abroad (df=8, X^2=30.2, p<0.001). Because this difference was significant, I reran the multiple linear regression model for professional skills with the categorical variable for time spent abroad included ("never" was used as the reference category). The results showed that EWB-USA membership and engineering service participation were still significantly higher in professional skills (OR=0.19 and 0.25, respectively, p<0.001 for both variables) than non-members and non-participants controlling for all other variables, even when time spent living abroad was a significant control variable.

The survey items from theme five (Appendix C) use items from Carberry (2010) to assess EWB-USA student members' perceived sources of learning. Results from each of the six technical skills and each of the nine professional skills were averaged across participants in Excel. On average, the students perceived that 41% of their technical skills came from coursework learning and that 61% of their professional skills came from EWB-USA participation. These results were similar to Carberry's findings (45% and 60% respectively).

CHAPTER 4

Quantitative analysis for Chapter 4 primarily consisted of creating a new data set, running descriptive statistics, and running logistic and ordinal logistic regression models. Variables for career skills were labeled with "eo" (originally representing "expected outcomes"), variables for students' career role expectations were labeled with "g" for goals, and variables for practicing engineers' career roles were labeled with "w" for work. The variable "svp" stands for "student versus practitioner" and is a dichotomous variable to distinguish the two groups where a student=1.

```
*Using the "Official EWB survey data.dta" file to create a new file for CH4

*Drop missing data for gender, age, svp status, skills outcomes questions, and career
   questions
drop if mi(female, age, svp, eo_ps, eo_hands, eo_teams, eo_ts, eo_creat, eo_lll,
   eo_aware, eo_pm, eo_pers, eo_comm, eo_sosaw, eo_global, eo_netw, eo_hum, eo_nont)
*196 dropped

*Reassign students 0's for practicing engineers' work roles questions
replace g_design=0 if svp==2
replace g_ngo=0 if svp==2
replace g_teach=0 if svp==2
replace g_research=0 if svp==2
replace g_pm=0 if svp==2
replace g_exman=0 if svp==2
```

```
replace g_mil=0 if svp==2
replace g_gov=0 if svp==2
replace g_other=0 if svp==2
replace g_home=0 if svp==2
replace g_enggrad=0 if svp==2
replace g_profdeg=0 if svp==2
drop if mi(g_design, g_ngo, g_teach, g_research, g_pm, g_exman, g_mil, g_gov, g_other,
   g_home, g_enggrad, g_profdeg)
*25 deleted

*Reassign practicing engineers 0's for students' work roles questions
replace w_design=0 if svp==1
replace w_ngo=0 if svp==1
replace w_teach=0 if svp==1
replace w_research=0 if svp==1
replace w_pm=0 if svp==1
replace w_exman=0 if svp==1
replace w_mil=0 if svp==1
replace w_gov=0 if svp==1
replace w_other=0 if svp==1
replace w_home=0 if svp==1
replace w_enggrad=0 if svp==1
replace w_profdeg=0 if svp==1
replace workchange=0 if svp==1
drop if mi(workchange, w_design, w_ngo, w_teach, w_research, w_pm, w_exman, w_mil,
   w_gov, w_other, w_home, w_enggrad, w_profdeg)
*17 deleted

*drop those in engineering service who are not in EWB
drop if ewbmem==0 & ewblike_part==3
drop if ewbmem==0 & ewblike_part==4
drop if ewbmem==0 & ewblike_part==5
*208 dropped, total of 2,228 left (614 EWBers or 28%)

*Descriptive stats for demographic data
tab female ewbmem, col chi2
tab svp ewbmem, col chi2
ttest age, by(ewbmem)
*for students
tab female ewbmem if svp==1, col chi2
ttest age if svp==1, by(ewbmem)
*for practitioners
tab female ewbmem if svp==2, col chi2
ttest age if svp==2, by(ewbmem)

*Ranks for career roles:
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if ewbmem==1 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if ewbmem==0 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if svp==1
summ w_design w_ngo w_teach w_research w_pm w_exman w_mil w_gov w_other w_home
   w_enggrad w_profdeg if svp==2
summ w_design w_ngo w_teach w_research w_pm w_exman w_mil w_gov w_other w_home
   w_enggrad w_profdeg if ewbmem==1 & svp==2
summ w_design w_ngo w_teach w_research w_pm w_exman w_mil w_gov w_other w_home
   w_enggrad w_profdeg if ewbmem==0 & svp==2

*Ranks for skills:
summ eo_ps eo_hands eo_teams eo_ts eo_creat eo_lll eo_aware eo_pm eo_pers eo_comm
   eo_sosaw eo_global eo_netw eo_hum eo_nont if svp==1
```

```
summ eo_ps eo_hands eo_teams eo_ts eo_creat eo_lll eo_aware eo_pm eo_pers eo_comm
   eo_sosaw eo_global eo_netw eo_hum eo_nont if svp==2
summ eo_ps eo_hands eo_teams eo_ts eo_creat eo_lll eo_aware eo_pm eo_pers eo_comm
   eo_sosaw eo_global eo_netw eo_hum eo_nont if svp==1 & ewbmem==1
summ eo_ps eo_hands eo_teams eo_ts eo_creat eo_lll eo_aware eo_pm eo_pers eo_comm
   eo_sosaw eo_global eo_netw eo_hum eo_nont if svp==1 & ewbmem==0
summ eo_ps eo_hands eo_teams eo_ts eo_creat eo_lll eo_aware eo_pm eo_pers eo_comm
   eo_sosaw eo_global eo_netw eo_hum eo_nont if svp==2 & ewbmem==1
summ eo_ps eo_hands eo_teams eo_ts eo_creat eo_lll eo_aware eo_pm eo_pers eo_comm
   eo_sosaw eo_global eo_netw eo_hum eo_nont if svp==2 & ewbmem==0


*Descriptive stats for student career goals
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if ewbmem==1 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if ewbmem==0 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if female==1 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if female==0 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if female==1 & ewbmem==1 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if female==1 & ewbmem==0 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if female==0 & ewbmem==1 & svp==1
summ g_design g_ngo g_teach g_research g_pm g_exman g_mil g_gov g_other g_home
   g_enggrad g_profdeg if female==0 & ewbmem==0 & svp==1

*Descriptive stats for interest in changing work:
tab workchange if svp==2
tab workchange ewbmem if svp==2
tab workchange female if svp==2
tab workchange ewbmem if female==1 & svp==2
tab workchange ewbmem if female==0 & svp==2

*Ordinal logistic regression for career skills (see Table 4-4)
ologit eo_ps age female ewbmem if svp==1, or
ologit eo_hands age female ewbmem if svp==1, or
ologit eo_teams age female ewbmem if svp==1, or
ologit eo_ts age female ewbmem if svp==1, or
ologit eo_creat age female ewbmem if svp==1, or
ologit eo_lll age female ewbmem if svp==1, or
ologit eo_aware age female ewbmem if svp==1, or
ologit eo_pm age female ewbmem if svp==1, or
ologit eo_pers age female ewbmem if svp==1, or
ologit eo_comm age female ewbmem if svp==1, or
ologit eo_sosaw age female ewbmem if svp==1, or
ologit eo_global age female ewbmem if svp==1, or
ologit eo_netw age female ewbmem if svp==1, or
ologit eo_hum age female ewbmem if svp==1, or
ologit eo_nont age female ewbmem if svp==1, or

ologit eo_ps age female ewbmem if svp==2, or
ologit eo_hands age female ewbmem if svp==2, or
ologit eo_teams age female ewbmem if svp==2, or
ologit eo_ts age female ewbmem if svp==2, or
ologit eo_creat age female ewbmem if svp==2, or
ologit eo_lll age female ewbmem if svp==2, or
ologit eo_aware age female ewbmem if svp==2, or
```

```
ologit eo_pm age female ewbmem if svp==2, or
ologit eo_pers age female ewbmem if svp==2, or
ologit eo_comm age female ewbmem if svp==2, or
ologit eo_sosaw age female ewbmem if svp==2, or
ologit eo_global age female ewbmem if svp==2, or
ologit eo_netw age female ewbmem if svp==2, or
ologit eo_hum age female ewbmem if svp==2, or
ologit eo_nont age female ewbmem if svp==2, or

*Ordinal logistic regression for student career interests (see Table 4-5)
ologit g_design age female ewbmem if svp==1, or
ologit g_ngo age female ewbmem if svp==1, or
ologit g_teach age female ewbmem if svp==1, or
ologit g_research age female ewbmem if svp==1, or
ologit g_pm age female ewbmem if svp==1, or
ologit g_exman age female ewbmem if svp==1, or
ologit g_mil age female ewbmem if svp==1, or
ologit g_gov age female ewbmem if svp==1, or
ologit g_other age female ewbmem if svp==1, or
ologit g_home age female ewbmem if svp==1, or
ologit g_enggrad age female ewbmem if svp==1, or
ologit g_profdeg age female ewbmem if svp==1, or

*Logistic regression for professional career experiences (see Table 4-5)
logit w_design age female ewbmem if svp==2, or
logit w_ngo age female ewbmem if svp==2, or
logit w_teach age female ewbmem if svp==2, or
logit w_research age female ewbmem if svp==2, or
logit w_pm age female ewbmem if svp==2, or
logit w_exman age female ewbmem if svp==2, or
logit w_mil age female ewbmem if svp==2, or
logit w_gov age female ewbmem if svp==2, or
logit w_other age female ewbmem if svp==2, or
logit w_home age female ewbmem if svp==2, or
logit w_enggrad age female ewbmem if svp==2, or
logit w_profdeg age female ewbmem if svp==2, or

*Logistic regression for professional career change
logit wchng_design ewbmem age female if svp==2, or
logit wchng_ngo ewbmem age female if svp==2, or
logit wchng_teach ewbmem age female if svp==2, or
logit wchng_research ewbmem age female if svp==2, or
logit wchng_pm ewbmem age female if svp==2, or
logit wchng_exman ewbmem age female if svp==2, or
logit wchng_mil ewbmem age female if svp==2, or
logit wchng_gov ewbmem age female if svp==2, or
logit wchng_other ewbmem age female if svp==2, or
logit wchng_home ewbmem age female if svp==2, or
logit wchng_enggrad ewbmem age female if svp==2, or
logit wchng_profdeg ewbmem age female if svp==2, or
logit wchng_nochng ewbmem age female if svp==2, or


*NOT INCLUDED IN DISSERTATION: Descriptive stats for professional career experiences
tab w_design if svp==2
tab w_ngo if svp==2
tab w_teach if svp==2
tab w_research if svp==2
tab w_pm if svp==2
tab w_exman if svp==2
tab w_mil if svp==2
tab w_gov if svp==2
tab w_other if svp==2
```

```
tab w_home if svp==2
tab w_enggrad if svp==2
tab w_profdeg if svp==2

tab w_design if ewbmem==1 & svp==2
tab w_ngo if ewbmem==1 & svp==2
tab w_teach if ewbmem==1 & svp==2
tab w_research if ewbmem==1 & svp==2
tab w_pm if ewbmem==1 & svp==2
tab w_exman if ewbmem==1 & svp==2
tab w_mil if ewbmem==1 & svp==2
tab w_gov if ewbmem==1 & svp==2
tab w_other if ewbmem==1 & svp==2
tab w_home if ewbmem==1 & svp==2
tab w_enggrad if ewbmem==1 & svp==2
tab w_profdeg if ewbmem==1 & svp==2

tab w_design if ewbmem==0 & svp==2
tab w_ngo if ewbmem==0 & svp==2
tab w_teach if ewbmem==0 & svp==2
tab w_research if ewbmem==0 & svp==2
tab w_pm if ewbmem==0 & svp==2
tab w_exman if ewbmem==0 & svp==2
tab w_mil if ewbmem==0 & svp==2
tab w_gov if ewbmem==0 & svp==2
tab w_other if ewbmem==0 & svp==2
tab w_home if ewbmem==0 & svp==2
tab w_enggrad if ewbmem==0 & svp==2
tab w_profdeg if ewbmem==0 & svp==2

tab w_design if female==1 & svp==2
tab w_ngo if female==1 & svp==2
tab w_teach if female==1 & svp==2
tab w_research if female==1 & svp==2
tab w_pm if female==1 & svp==2
tab w_exman if female==1 & svp==2
tab w_mil if female==1 & svp==2
tab w_gov if female==1 & svp==2
tab w_other if female==1 & svp==2
tab w_home if female==1 & svp==2
tab w_enggrad if female==1 & svp==2
tab w_profdeg if female==1 & svp==2

tab w_design if female==0 & svp==2
tab w_ngo if female==0 & svp==2
tab w_teach if female==0 & svp==2
tab w_research if female==0 & svp==2
tab w_pm if female==0 & svp==2
tab w_exman if female==0 & svp==2
tab w_mil if female==0 & svp==2
tab w_gov if female==0 & svp==2
tab w_other if female==0 & svp==2
tab w_home if female==0 & svp==2
tab w_enggrad if female==0 & svp==2
tab w_profdeg if female==0 & svp==2

tab w_design if female==1 & ewbmem==1 & svp==2
tab w_ngo if female==1 & ewbmem==1 & svp==2
tab w_teach if female==1 & ewbmem==1 & svp==2
tab w_research if female==1 & ewbmem==1 & svp==2
tab w_pm if female==1 & ewbmem==1 & svp==2
tab w_exman if female==1 & ewbmem==1 & svp==2
tab w_mil if female==1 & ewbmem==1 & svp==2
```

```
tab w_gov if female==1 & ewbmem==1 & svp==2
tab w_other if female==1 & ewbmem==1 & svp==2
tab w_home if female==1 & ewbmem==1 & svp==2
tab w_enggrad if female==1 & ewbmem==1 & svp==2
tab w_profdeg if female==1 & ewbmem==1 & svp==2

tab w_design if female==1 & ewbmem==0 & svp==2
tab w_ngo if female==1 & ewbmem==0 & svp==2
tab w_teach if female==1 & ewbmem==0 & svp==2
tab w_research if female==1 & ewbmem==0 & svp==2
tab w_pm if female==1 & ewbmem==0 & svp==2
tab w_exman if female==1 & ewbmem==0 & svp==2
tab w_mil if female==1 & ewbmem==0 & svp==2
tab w_gov if female==1 & ewbmem==0 & svp==2
tab w_other if female==1 & ewbmem==0 & svp==2
tab w_home if female==1 & ewbmem==0 & svp==2
tab w_enggrad if female==1 & ewbmem==0 & svp==2
tab w_profdeg if female==1 & ewbmem==0 & svp==2

tab w_design if female==0 & ewbmem==1 & svp==2
tab w_ngo if female==0 & ewbmem==1 & svp==2
tab w_teach if female==0 & ewbmem==1 & svp==2
tab w_research if female==0 & ewbmem==1 & svp==2
tab w_pm if female==0 & ewbmem==1 & svp==2
tab w_exman if female==0 & ewbmem==1 & svp==2
tab w_mil if female==0 & ewbmem==1 & svp==2
tab w_gov if female==0 & ewbmem==1 & svp==2
tab w_other if female==0 & ewbmem==1 & svp==2
tab w_home if female==0 & ewbmem==1 & svp==2
tab w_enggrad if female==0 & ewbmem==1 & svp==2
tab w_profdeg if female==0 & ewbmem==1 & svp==2

tab w_design if female==0 & ewbmem==0 & svp==2
tab w_ngo if female==0 & ewbmem==0 & svp==2
tab w_teach if female==0 & ewbmem==0 & svp==2
tab w_research if female==0 & ewbmem==0 & svp==2
tab w_pm if female==0 & ewbmem==0 & svp==2
tab w_exman if female==0 & ewbmem==0 & svp==2
tab w_mil if female==0 & ewbmem==0 & svp==2
tab w_gov if female==0 & ewbmem==0 & svp==2
tab w_other if female==0 & ewbmem==0 & svp==2
tab w_home if female==0 & ewbmem==0 & svp==2
tab w_enggrad if female==0 & ewbmem==0 & svp==2
tab w_profdeg if female==0 & ewbmem==0 & svp==2
```

Results from the descriptive statistics of students' career interests and practitioners' career experiences were not included in Chapter 4; however, the results were exported into Excel and are presented in the three figures below.

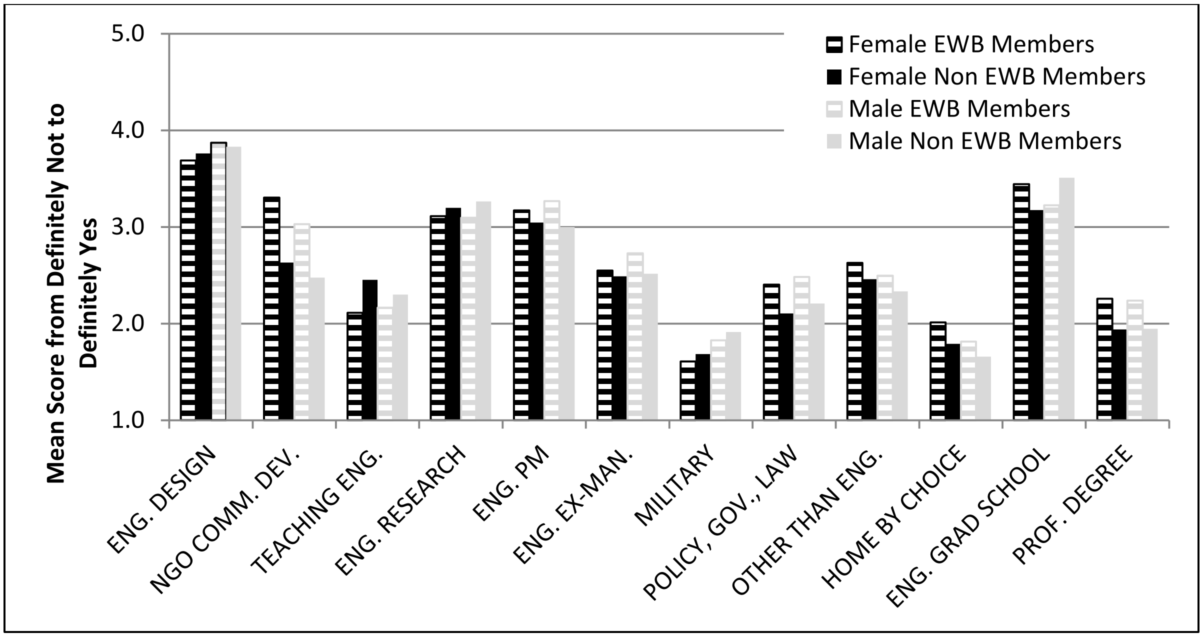

Figure D-3: Student career goals by EWB-USA membership and gender

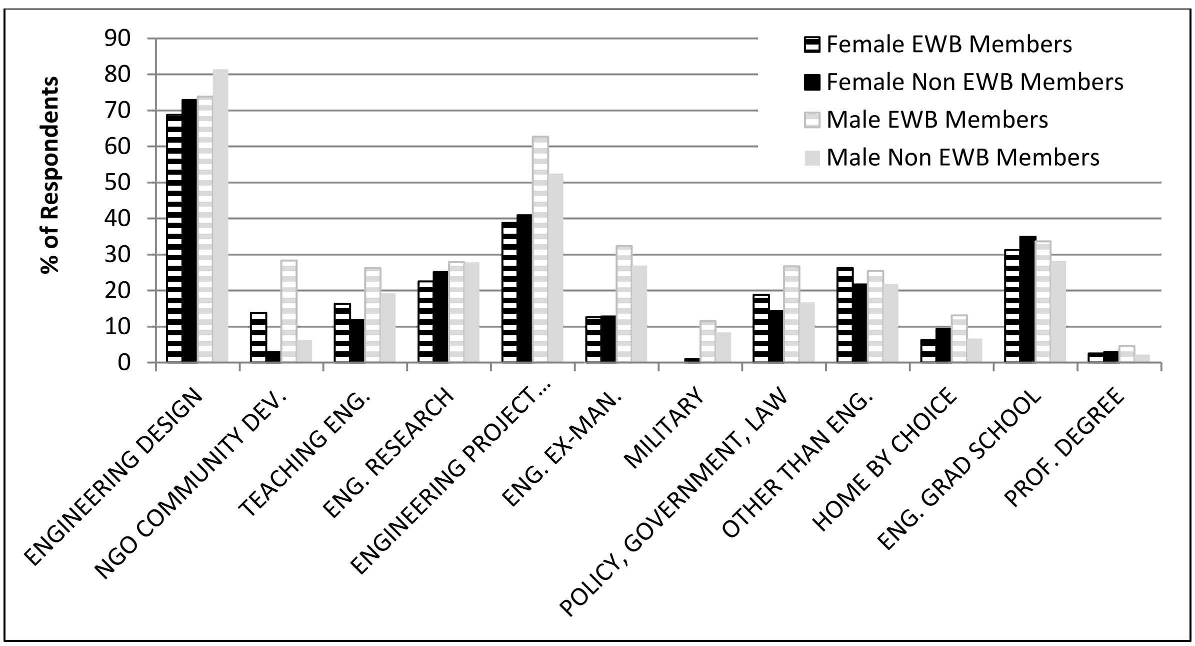

Figure D-4: Practitioners' work experiences by EWB-USA membership and gender

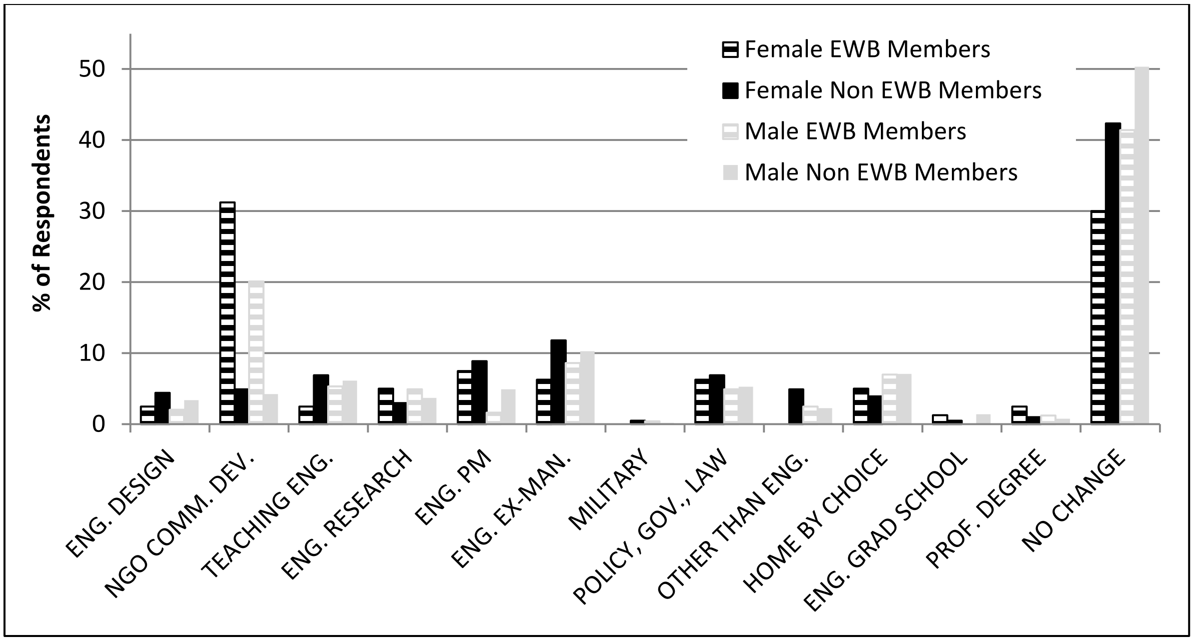

Figure D-5: Practitioners' interest in changing careers by EWB-USA membership and gender

REFERENCES

Carberry, A. R. (2010). "Characterizing Learning-Through-Service Students in Engineering by Gender and Academic Year." Tufts University, Medford, MA.

UC Berkeley. (2013). "Construct Map." *UC Berkeley BEAR Center*, <https://bearcenter.berkeley.edu/software/constructmap> (Oct. 20, 2013).

APPENDIX E: LESSONS LEARNED

In this appendix I discuss some of the lessons I learned about my research topic and methods to supplement this dissertation and to inform future researchers.

POSITIONALITY AND POTENTIAL BIASES

The use of qualitative analysis taught me about researcher bias. Having been educated as an engineer, I was trained to see the world through a positivistic lens in which I was an objective researcher uncovering truth that existed in the world. Thankfully, I learned that positivism has not only been widely refuted but that there are multiple ways to both view and come to know reality. After being exposed to alternative traditions of scholarship including constructive, critical, interpretive and postmodern practices, I best identified with Joseph Maxwell's critical realist approach (Maxwell 2012). Maxwell makes the case that critical realism combines ontological realism and epistemological constructivism, which allows for multiple, partial yet valid perspectives on one complex reality. Critical realists believe that truth exists in the world, but that it is difficult to know entirely; therefore, their approach to qualitative research values a large and diverse data set to offer multiple perspectives and treats the data as offering a partial yet true glimpse of reality. With a critical realist perspective, I believed that my study was trying to understand reality and that each participant offered valid yet limited perspectives of reality, which I would combine to better understand the truth about socially engaged engineers.

I attempted to maintain a positionality of outside observer throughout the research. In interviews and focus groups, the research team and I introduced ourselves as university-affiliated researchers. When soliciting non-EWB member participants, we introduced the study as one focused on understanding engineers and how organizational involvement can help to inform changes for engineering curricula. Similarly, during the survey phase, we positioned the survey as university-affiliated and funded by the NSF to learn about engineering education. We did our best to minimize the focus on EWB-USA throughout data collection to minimize the bias. Naturally, because we were interested in EWB-USA, the topic was addressed in each interview or focus group; however, we made it clear that we were not affiliated with EWB-USA. The majority of participants appeared comfortable to share their honest opinions about their education, work experience, and experiences with EWB-USA or other organizations. For example, a woman in a focus group stopped mid-sentence to ask, "*Is this confidential?*" (FEP8) and then proceeded to share her indecision about leaving her job. Other participants appeared comfortable through swearing (e.g., MEP26, MEP28) or through sharing their criticisms about their jobs, education, and organizations (including EWB-USA); most participants did not appear to be filtering their responses to be positive or polite. This level of honesty provided evidence against respondent duplicity and respondents' trust in my positionality.

Despite the best intentions to remain unbiased, I carried inherent biases into this study. As a female engineer, I was more keenly aware of gender biases in engineering than a male or non-engineer may have been, and I was more intrigued by the improved gender balance within EWB-USA than a male may have been. This interest may have exposed and drawn me towards studies and theories exploring gender differences in science and engineering, such as expectancy-value theory (Eccles 1994). Although male focus group leaders were used when possible, the majority of the focus groups and all of the interviews were led by female researchers, which could have made some males less comfortable to speak their minds about gender issues. For example, perhaps, when asked about why they think there may be more women involved with EWB-USA than other engineering settings, male participants felt compelled to give an answer that was sensitive to the females in the room. Because gender was not a primary topic explored further in the qualitative analysis, this bias likely did not influence the results heavily.

Another inherent bias that I brought to the study was from being a socially engaged engineer myself. Because I had been involved with non-profit humanitarian engineering organizations and an engineering curricular program for sustainable community development, I brought my own interest and experience with socially engaged engineering to the study. This interest and experience helped me be able to speak the language of such work with participants and be motivated to pursue this research topic; however, my positive experiences may have biased me in favor of such experiences, especially early on. As I progressed in the research and came to better understand the literature and fields of humanitarian engineering, service-learning, international development, etc., I began to understand the criticisms about such work. I believe that this exposure to the criticisms and the many nuanced differences within different terms that I have grouped into socially engaged engineering improved my research because it helped me take a more objective approach. For example, I was better able to consider the potentially confounding variables in the quantitative analyses that should be controlled for to rule out alternative explanations for differences between EWB-USA members and non-members. I sense that this progression is noticeable in my work and that it has made me a better researcher—one that is more aware of biases and engaged in critical analysis. Had a researcher who was not a socially engaged engineer performed this work, I imagine that similar results would still have been found—meaning that a different type of engineer would have been identified among EWB-USA members—however, I cannot say how the results would have differed because any other researcher would bring his or her own biases too. If non-engineer researchers were to take up this work, coming from a less positivistic tradition could help favor the qualitative data even more than I did and provide a compelling ethnographic account of the culture of socially engaged engineers.

Another bias within this research was the focus on EWB-USA as a case of socially engaged engineering. This decision was made for many reasons outlined in the dissertation, and despite the use of large data sets, theoretical generalizability, and the inclusion of other engineering service organizations where possible, the focus on EWB-USA still biases this research on socially engaged engineers towards the EWB-USA member. Many other socially engaged engineering organizations exist that take a different approach than EWB-USA, for example, curricular programs like EPICS at Purdue (Coyle et al. 2005) or long-term in-country experiences like the Peace Corps. A focus on EWB-USA biases this study of socially engaged engineers towards shorter term, project based experiences in small and relatively low-income international communities. This is one among many possible applications for socially engaged engineers, and as mentioned in Chapter 5, should be explored further in future research.

STRENGTHS OF THIS STUDY

Alongside the biases and limitations within this research, there were many strengths. First, an important strength was its exploratory approach because this was a relatively unstudied topic. Through the qualitative research and discussions with the research team, a frequent and important question that came up was, "Does EWB-USA involvement *make* these engineers or does it *attract* these engineers?" This question, which was regularly asked by our team and those interested in our research, including research participants, was based on the assumption that EWB-USA engineers were somehow different than other engineers. It was as if people already knew this assumption to be true and wanted to ask *why* it was true rather than test the assumption. Therefore, we recognized that this assumption—that there were differences between EWB-USA members and non-members—needed to be understood. Through the exploratory process, the main research question emerged.

The exploratory approach also dictated the sequence of qualitative data followed by quantitative data (Creswell 2009). As shown in Appendix C, the survey development relied heavily on the initial findings from the qualitative data, which was a strength of this study. Rather than create a survey with preconceived themes of interest, the team allowed the themes of the qualitative findings to inform the scales selected or created for the survey. I believe that this survey creation phase, including the use of a large-scale pilot study, was a strength of this study, which I would use again in another exploratory project.

Another strength of this study was the size of the data sets. Thanks to our helpful contacts at EWB-USA, ASCE, ASME, SWE, and the University of Colorado, Boulder, we were able to reach 165 qualitative participants and a survey respondent population of 2,674 people. This volume of data improved the power of the statistical tests and the range and depth of the qualitative responses.

A valuable progression from the pilot survey analysis to the official survey analysis moved from Mann-Whitney U tests of comparison to linear and logistic regression models. The non-parametric tests of comparisons used on the pilot survey data compared the Likert-items without the assumptions necessary for parametric tests of comparisons; however, they could not control for differences such as gender, age, GPA, etc., which were clearly significant between our two populations of interest. The regression models were a major improvement to the quantitative analyses, and became an important strength of this study. Statistical analyses within engineering research is often based on experimental research design where the controls are built into the experiment; however, the study of people requires observational research in which statistical controls are necessary in place of experimental controls. The use of regression analyses to statistically control for potentially confounding variables made this study more robust.

Measurement theory also added strength to this study. Because an important aspect of this study was to measure human traits, which cannot be measured in a positivist tradition, pragmatic tools were necessary. In Chapter 2, I used existing scales to measure motivations and personality traits, and in Chapter 4, I used self-created list of career roles, which were less about measuring specific attributes and more about exploring interests and experiences; however, in Chapter 3, I wanted to measure technical and professional engineering skills using responses to Likert items, which had not been done before. As explained in Appendix D, the use of Construct Map software to created continuous measures of these skills based on item response theory, was a novel method employed to measure these skills. The use of this theory and software greatly strengthened the results in this chapter and provided methods to improve additional scales used in research of human attributes. The field of engineering education research has much to learn from the field of educational research, and the areas of this research that crossed disciplines from engineering into education were important strengths of this study.

Additional suggested changes and future research

Although Chapter 5 suggested future research areas, here I share more detailed suggestions for improving this research from the lessons I have learned along the way. First, I suggest two specific theories for future research on this topic. The first is expectancy-value theory (Eccles 1994), which provides a thorough and well-studied theory of how people make achievement-related choices, particularly in how they make choices about their careers. Although many other theories exist to study similar ideas, after performing my research, the robustness of this theory has stuck out to me and is one I wished I had time to dig into further. Another theory that can provide important insight for research on socially engaged engineers is one that understands how engineers develop a sense of social responsibility (Canney and Bielefeldt 2014). This framework is promising for future research to answer the question of why EWB-USA members and non-members are different. Although alternative theories should also be explored, applying one consistent theory to future research on this topic is a suggestion rising from this initial exploratory research, and these two theories are ones that I have grown to value over my research.

Through learning about qualitative research from educational researchers, I grew an appreciation for ethnographic research (or educational anthropology). This methodology is more in line with Maxwell's critical realist perspective which values understanding people by watching them in context (similar to situated learning theory (Lave and Wenger 1991)). Although the qualitative research in this study incorporated many diverse participants, I suggest that a more ethnographic approach would provide a stronger understanding to the culture of socially engaged engineers that could provide additional insight which interviews and focus groups could not reach. This research could provide important information to initiate such a study.

Another suggestion comes from reflecting about the generalizability of this study. In order to improve the generalizability of this study, it would have been ideal to have a random sample of engineers from around the world without having to limit the population to engineers in the US and engineers associated with four specific engineering organizations. This meant that survey results were generalizable to comparisons of EWB-USA members and members of these organizations who were not involved with EWB-USA. The question that remains is: Are ASCE, ASME, and SWE representative of the US engineering population and is EWB-USA representative of socially engaged engineers? Are there major differences between engineers who do and do not become members of these organizations? The sample of ASCE, ASME, and SWE leaves out many disciplines such as chemical or electrical engineers and those engineers who have opted not to maintain membership with their field's professional engineering organization, such as those who may work outside of their engineering discipline. After performing the research, I wonder if this change would show differences or not, particularly in the results for the career roles. For example, those engineers who may now be working in community development roles may be underrepresented in the survey population. Because a random sample of all engineers in the US would be nearly impossible to get, this research did well to achieve a large and diverse sample, but improvements such as those mentioned are always possible.

A more detailed suggested change after performing this research is to avoid Likert-style items in survey research of people. Because my survey was so large and attempted to explore many different scales, the use of existing scales was helpful; however, after learning about the extensive debate concerning the analysis of Likert-style items, I suggest reconsidering the style of items used in the survey. Likert-style items have been analyzed as continuous data, categorical data, and ordinal data depending on researchers' preferences. Although the continuous data approach allows researchers to use more powerful statistical tests than the other two approaches, this approach often neglects the important assumptions associated with parametric data and assumptions that presume response categories are equidistant. For future research, I first suggest the use of measurement theory to better understand the construct of interest, and then I suggest a survey with non-Likert items, such as Guttman items (Wilson 2005), that can be more easily interpreted using measurement theory. This approach allows for stronger assessment of validity between items, responses, and the construct of interest, and it allows for the use of powerful statistical analyses through the use of item response theory (such as the approach taken in Chapter 3). After learning about this approach, I suggest all future quantitative research concerning the study of people approach measurement with this type of rigor.

Another suggested change is to account for measurement error in the survey data analysis. Corrections for attenuation (disattenuation methods) improve correlation coefficients from the effects of measurement error. This research did not apply correction formulas to account for measurement error, therefore, coefficients as reported are likely to be biased towards zero due to the measurement error in the scales. Thus, all reported coefficients may be conservative estimates of the true relationships. For more accurate coefficients, future research could either apply correction formulas to the original models or account for measurement error directly through random effects in new latent regression models.

FAVORITE TIPS AND TRICKS

After extensive qualitative and quantitative analyses, I have grown preferences for certain software and tools within specific software. I spent the majority of my time doing analysis in NVivo 10 (QSR International 2013), which I found to be extremely useful. A few of my favorite tools within NVivo included its auto-coding functions for importing both spreadsheets and interview transcripts. The auto-code features sped up the macro coding extensively. I advise future researchers, particularly those with large amounts of data, to take the time to learn about these features prior to importing data into NVivo so that they can be used. The query features within NVivo were employed regularly to explore the data. The matrix coding query was especially useful to compare groups and to determine relative frequencies. This feature is best utilized when nodes for both participants (or cases more generally) and content are used. My other favorite tool within NVivo was the memo writing feature with "see also links," which allowed me to connect part of my written memo to text from a specific transcript. This feature made memo writing extremely helpful, and I highly recommend its use for researchers writing summaries about their qualitative data.

Two other software programs I used extensively in this research were Stata and Qualtrics. Although I did not explore other survey software programs, Qualtrics survey software was a great choice. It provides, among many other things, helpful tutorials for quickly learning the software, lots of options for different question types, sharing features to work as a team, a simple interface to create, preview, and distribute surveys, and straightforward preferences to download the results. I recommend this software for electronic surveys. In addition, I recommend Stata as a statistical software program. I used both R and SPSS prior to using Stata, and I found that Stata was a satisfying compromise between the other two. SPSS offers ease and accessibility of the data with a sort of "black box" effect where it is easy to run analyses without knowing what is happening, and R offers more freedom and control to the user but can feel as though the data is hiding and inaccessible. I enjoyed coding in Stata because I felt I had the control I liked within R, but the features such as the variable manager allowed me to view my data when I needed to. Although I enjoyed Stata, as most engineers are, I am most comfortable in Excel. Therefore, for other engineers working in Stata, I recommend exporting data from Qualtrics to Excel first and cleaning up the data (as shared in Appendix D) in Excel prior to importing the data into Stata. This step made the work in Stata much smoother.

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APPENDIX F: IRB APPROVALS

The following six pages document the IRB approval letters for the following dates and reasons:

1. March 16, 2011: Initial approval
2. April 3, 2012: Amendment approval
3. March 4, 2013: Amendment approval
4. March 5, 2013: Continuing review approval
5. September 25, 2013: Amendment approval
6. February 18, 2014: Continuing review approval

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University of Colorado Boulder

16-Mar-2011

Initial Approval - Expedited

Kaminsky, Jessica
Protocol #: 11-0049
Title: Collaborative Research: Gender Diversity, Identity and EWB-USA

Dear Jessica Kaminsky,

The Institutional Review Board (IRB) has approved this protocol in accordance with Federal Regulations at 45 CFR 46. You must use the IRB approved informed consent form when obtaining consent from subjects participating in this protocol.

Initial Approval Date: 16-Mar-2011
Expiration Date: 15-Mar-2012
Associated Documents:* Updated Protocol; Updated Participant Registration Form; Revised Procotcol Document 2; Updated Consent Script; Participant Registration Form; Survey Questions; Conference Recruitment Fliers; Protocol; Initial Application - eForm v2;
Number of subjects approved:20000
Review Cycle: 12 months
Expedited Category: 7

* Approved documents can be found by logging into the eRA system, opening this protocol, and navigating to the "Versions" folder.

Regulations require that this protocol be renewed prior to the above expiration date. The IRB will provide a reminder prior to the expiration date, but it is your responsibility to ensure that the continuing review form is received in sufficient time to be reviewed prior to the expiration date.

Changes to your protocol must be submitted to the IRB for review and approval prior to their implementation. This includes changes to the consent form, principal investigator, protocol, etc.

All events that meet reporting criteria must be submitted within 10 business days from notification of the event. Any study-related death must be reported immediately (within 24 hours) upon learning of the death.

The IRB has approved this protocol in accordance with federal regulations, university policies and ethical standards for the protection of human subjects. In accordance with federal regulation at 45 CFR 46.112, research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the institution. The investigator is responsible for knowing and complying with all applicable research regulations and policies including, but not limited to, Environmental Health and Safety, Scientific Advisory and Review Committee, Clinical and Translational Research Center, and Wardenburg Health Center and Pharmacy policies. Approval by the IRB does not imply approval by any other entity.

Please contact the IRB office at 303-735-3702 if you have any questions about this letter or about IRB procedures.

Douglas Grafel
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03-Apr-2012

Amendment Approval - Expedited

Litchfield, Kaitlin
Protocol #: 11-0049
Title: Collaborative Research: Gender Diversity, Identity and EWB-USA

Dear Kaitlin Litchfield,

The Institutional Review Board (IRB) has approved the amendment described below in accordance with Federal Regulations at 45 CFR 46. You must use the IRB approved informed consent form when obtaining consent from subjects participating in this protocol.

Approval Date: 03-Apr-2012
Expiration Date: 21-Mar-2013
Number of Subjects: 20000

Associated Documents:* 11-0049 Consent Form (3Apr12); 11-0049 Protocol (3Apr12); Updated Protocol; Activity Form; Open Ended Questions; Consent Form; Conference Recruitment; CITI Training Certificates; Amendment - eForm;
Description of Amendment: Change of PI to Kaitlin Litchfield, change of Faculty Advisor to Amy Javernick-Will. Amendment also includes new data collection activity, involving undergraduate students responding to questions regarding identity formation in engineering per attached forms.

*** To find the approved documents log into eRA, open this protocol, expand the Management folder, and click on the Versions subfolder.**

This approval DOES NOT change the expiration date of your protocol.

The IRB has approved this amendment in accordance with federal regulations, university policies and ethical standards for the protection of human subjects. In accordance with federal regulation at 45 CFR 46.112, research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the institution. The investigator is responsible for knowing and complying with all applicable research regulations and policies including, but not limited to, Environmental Health and Safety, Scientific Advisory Committee, Clinical and Translational Research Center, and Wardenburg Health Center and Pharmacy policies. Approval by the IRB does not imply approval by any other entity.

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04-Mar-2013

Amendment Approval - Expedited

Litchfield, Kaitlin
Protocol #: 11-0049
Title: Collaborative Research: Gender Diversity, Identity and EWB-USA

Dear Kaitlin Litchfield,

The Institutional Review Board (IRB) has approved the amendment described below in accordance with Federal Regulations at 45 CFR 46. You are required to use copies of the stamped IRB approved consent forms. You can access the document(s) by clicking the Approved Documents link below.

Approval Date: 04-Mar-2013
Expiration Date: 21-Mar-2013
Documents Approved: 11-0049 Consent Form (4Mar13); 11-0049 Protocol (4Mar13);
Documents Reviewed: CITI Training for Undergraduate RA; HRP-213: FORM - Amendment;
Description of Amendment: Update to Study Personnel.

Click here to find the approved documents for this protocol: Approved Documents

This approval DOES NOT change the expiration date of your protocol.

The IRB has approved this amendment in accordance with federal regulations, university policies and ethical standards for the protection of human subjects. In accordance with federal regulation at 45 CFR 46.112, research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the institution. The investigator is responsible for knowing and complying with all applicable research regulations and policies including, but not limited to, Environmental Health and Safety, Scientific Advisory Committee, Clinical and Translational Research Center, and Wardenburg Health Center and Pharmacy policies. Approval by the IRB does not imply approval by any other entity.

Please note change as of October 8, 2012: If you have any informed consent, assent, or parental permission forms, the IRB has administratively revised the header of these documents to reflect the current template. For your reference the IRB approval date has been revised due to this change. As indicated on our website, expiration dates are no longer included on the documents. Please ensure you are using the correct IRB Approved versions of all documents throughout your study.

Please contact the IRB office at 303-735-3702 if you have any questions about this approval or about IRB procedures.

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05-Mar-2013

Continuing Review Approval - Expedited

Litchfield, Kaitlin
Protocol #: 11-0049
Title: Collaborative Research: Gender Diversity, Identity and EWB-USA

Dear Kaitlin Litchfield,

The Institutional Review Board (IRB) has approved this continuing review in accordance with Federal Regulations at 45 CFR 46. You are required to use copies of the stamped IRB approved consent forms. You can access the document(s) by clicking the Approved Documents link below.

Approval Date: 05-Mar-2013
Expiration Date: 04-Mar-2014
Documents Approved:
Documents Reviewed: HRP-212: FORM - Continuing Review;
Review Cycle: 12 months
Expedited Category: 7

Click here to find the approved documents for this protocol: Approved Documents

Regulations require that this protocol be renewed prior to the above expiration date. The IRB will provide a reminder prior to the expiration date, but it is your responsibility to ensure that your continuing review is received in sufficient time to be reviewed prior to the expiration date.

Changes to your protocol must be submitted to the IRB for review and approval prior to their implementation. This includes changes to the consent form, principal investigator, protocol, etc.

All events that meet reporting criteria must be submitted within 5 business days from notification of the event. Any study-related death must be reported immediately (within 24 hours) upon learning of the death.

The IRB has approved this protocol in accordance with federal regulations, university policies and ethical standards for the protection of human subjects. In accordance with federal regulation at 45 CFR 46.112, research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the institution. The investigator is responsible for knowing and complying with all applicable research regulations and policies including, but not limited to, Environmental Health and Safety, Scientific Advisory and Review Committee, Clinical and Translational Research Center, and Wardenburg Health Center and Pharmacy policies. Approval by the IRB does not imply approval by any other entity.

Please note change as of October 8, 2012: If you have any informed consent, assent, or parental permission forms, the IRB has administratively revised the header of these documents to reflect the current template. For your reference the IRB approval date has been revised due to this change. As indicated on our website, expiration dates are no longer included on the documents. Please ensure you are using the correct IRB Approved versions of all documents throughout your study.

Please contact the IRB office at 303-735-3702 if you have any questions about this letter or about IRB procedures.

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25-Sep-2013

Amendment Approval - Expedited

Litchfield, Kaitlin
Protocol #: 11-0049
Title: Collaborative Research: Gender Diversity, Identity and EWB-USA

Dear Kaitlin Litchfield,

The Institutional Review Board (IRB) has approved the amendment described below in accordance with Federal Regulations at 45 CFR 46.

Approval Date: 25-Sep-2013
Expiration Date: 04-Mar-2014
Documents Approved: 11-0049 Survey Consent (25Sep13); 11-0049 Protocol (25Sep13); Survey Questions and Recruitment (25Sep13);
Documents Reviewed: HRP-213: FORM - Amendment;
Description of Amendment: Addition of Phase III survey procedures and associated documents.

Click here to find the approved documents for this protocol: Approved Documents

This approval DOES NOT change the expiration date of your protocol.

The IRB has approved this amendment in accordance with federal regulations, university policies and ethical standards for the protection of human subjects. In accordance with federal regulation at 45 CFR 46.112, research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the institution. The investigator is responsible for knowing and complying with all applicable research regulations and policies including, but not limited to, Environmental Health and Safety, Scientific Advisory Committee, Clinical and Translational Research Center, and Wardenburg Health Center and Pharmacy policies. Approval by the IRB does not imply approval by any other entity.

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18-Feb-2014

Continuing Review Approval - Expedited

Litchfield, Kaitlin
Protocol #: 11-0049
Title: Collaborative Research: Gender Diversity, Identity and EWB-USA

Dear Kaitlin Litchfield,

The Institutional Review Board (IRB) has approved this continuing review in accordance with Federal Regulations at 45 CFR 46.

Approval Date: 18-Feb-2014
Expiration Date: 17-Feb-2015
Documents Approved:
Documents Reviewed: HRP-212: FORM - Continuing Review;
Review Cycle: 12 months
Expedited Category: 7

Click here to find the approved documents for this protocol: Approved Documents

Regulations require that this protocol be renewed prior to the above expiration date. The IRB will provide a reminder prior to the expiration date, but it is your responsibility to ensure that your continuing review is received in sufficient time to be reviewed prior to the expiration date.

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